WARREN'S NEW PHYSICAL GEOGRAPHY

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LELAND STANFORD JUNIOR UNIVERSITY

COMMENT:

WARREN'S

NEW

PHYSICAL GEOGRAPHY

BY

WILLIAM H. BREWER, PH. D.

PROFESSOR IN YALE UNIVERSITY

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PREFACE.

SINCE the publication of the earliest edition of WARREN'S PHYSICAL GEOGRAPHY, the first popular treatise on the subject issued in this country, that work has been revised from time to time to keep pace with the advance of knowledge in this branch of learning. But with the rapid progress of modern science old theories are continually changing, or are one by one dismissed as incapable of explaining observed facts, and with the additions to the fund of knowledge revisions of old hypotheses become necessary.

Under these conditions it has been considered advisable to prepare a new book, in which the facts and phenomena of the physical world are presented in the light of recent scientific investigation, while such methods of treatment are employed as have for more than thirty years maintained the popularity of the original treatise.

The aim of this work is to discuss in a popular and elementary style some of the more familiar physical features of the earth; the character of its land-surface, the nature and movements of the water and of the atmosphere, and their relations to and influence upon one another, as well as their combined effect upon the different forms of organic life. The development of this plan is simple, logical, and comprehensive. The treatment is sufficiently full to afford a general view of the subject, while the interest of the student is not distracted by too great a mass of details. It is not the province of a work of this character to give a complete outline of all the various departments of natural science, but it is essential to select from each such accepted facts and theories as may elucidate the present conditions of the earth's surface or assist in explaining the more important phenomena.

In this respect it is believed that the present work will be found eminently successful. The various phases of nature, as exhibited on the earth, in the air, or in the water, and their simple or complex relations to one another, are explained by facts drawn from collateral sciences and considered from the standpoint of Physical Geography. The relation of this globe to other heavenly bodies, its shape, its motions, the manner in which light and heat are received from the sun, and other features of astronomical environment, are studied with reference to their bearing upon the resulting conditions of life. The long geological ages, during which the earth underwent continual transformation, are viewed as periods of change necessary to prepare it for its present inhabitants. The previous and progressive stages in the development of organized beings are considered in relation to existing species. It is not the details of Botany and Zoology that are sought, but the effects produced by the disposition of land and water, by relief, by climate, and by abundance of rainfall upon the distribution of animals and plants, or the results of this distribution upon the welfare of the human race. Such considerations as these, and the modifications of nature produced by living creatures and by civilized man, constitute the characteristics of the treatment of organic life.

The subordinate divisions of the book are in every case followed by a number of suggestive questions for the aid of pupil and teacher, and a page of review and map questions is placed at the close of each principal section.

The subject-matter has been carefully prepared under the direction of Professor William H. Brewer, of Yale University. The general arrangement of the book and the editing of the proof-sheets have been superintended by Mr. F. B. Greene. Acknowledgments are due to many friends and educators for suggestions, criticisms, and contributions, particularly to Major J. W. Powell, Director of the United States Geological Survey, Dr. Charles W. Greene, Professor E. W. Blake, of Brown University, and Mr. Jacques W. Redway.

The maps form an especially valuable feature of the work. The colored maps have been prepared on a much larger scale than is customary in school-books of this kind, and embody the results of the latest researches in the various departments of physical science. In addition to these larger charts, there are numerous smaller maps designed to illustrate special subjects: all of these maps have been engraved from original drawings by M. Alfred Durin. The elaborate geological map of the United States is the first of the kind ever published in a school text-book, and was prepared under the direct supervision of Major J. W. Powell, Director of the United States Geological Survey, and his able corps of assistants. The series of relief maps will be found to be of special value in conveying to the pupil a correct idea of the surface structure of the various land-masses. They have been reproduced with great care from models made especially for this work.

In addition to the numerous diagrams used to present in graphic form the facts and conditions which are treated in the text, there are carefully-executed pictorial illustrations, valuable not only on account of their artistic merit, but also as practical educational aids. Many of these have been engraved from photographs, and the excellent instantaneous photograph of lightning has been reproduced by permission of Mr. A. H. Binden. The original designs were furnished by such artists as Simon, Redwood, Schell, Moran, Yeager, and Lummis. The cuts were engraved by Lindsay, Reed, G. P. Williams, Rea, Heiss, Irwin, and L. S. Williams.

It is believed that this volume embodies, both in choice of material and in the mode of treatment, the best results of the thought and experience of earnest and practical educators, and it is hoped that the present treatise may receive the same approval and commendation that for so many years have been bestowed upon the former work.

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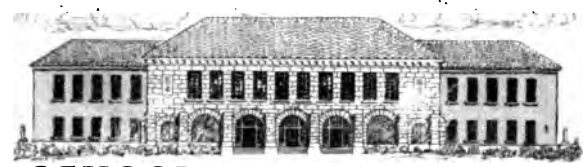

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26. The parallels lie north and south from the equator. The equator is numbered zero (0), and the other parallels are numbered 1 to 90, north and south of the equator.

27. The **Latitude** of a place is its distance in degrees and parts of a degree from the equator, measured north or south.

The degrees into which the meridians are divided are called *degrees of latitude;* those into which the parallels are divided, *degrees of longitude;* and if we know the longitude and latitude of a place, we know its position upon the earth's surface.

Each degree of latitude and longitude is divided into sixty equal parts, called *minutes;* and each minute into sixty *seconds.*

28. The parallels are crossed by the meridians in the same manner as the equator, and therefore each parallel is divided into 360 degrees. But, as the parallels grow smaller as we approach the poles, the *degrees* into which they are divided grow *proportionately smaller.*

29. Degrees are designated by a small circular figure (°), written a little to the right and above the number; minutes, by one mark (′); and seconds, by two marks (″).

Example.—The position of Chicago is designated thus: Chicago, 41° 53′ 6″ N. Lat., and 87° 38′ 1″ W. Long.; which reads, forty-one degrees, fifty-three minutes, and six seconds north latitude, and eighty-seven degrees, thirty-eight minutes, and one second west longitude from Greenwich.

30. The superficial area of the earth is 197,000,000 square miles.

The diameter of the earth at the equator is 7925.65 miles.

The earth's axis is 7899.17 miles long, or 26.48 miles shorter than the equatorial diameter. The circumference of the earth on the equator is 24,899 miles, or, in round numbers, the diameter is about 8000 miles, and the circumference about 25,000.

As every circle, whatever its size, is divided into 360 degrees, it is clear that the degrees in circles having different diameters must differ in actual length. A degree of longitude on the equator is 69.124 statute (or common) miles, and the length of the degree diminishes either north or south until it becomes 0 at the poles. A degree of latitude at the equator is 68.502 statute miles, but, as the earth is flattened at the poles, a degree increases there to 69.124 statute miles. A statute mile is 5280 feet; a geographical mile and a nautical mile, or a knot at sea, are each 6080 feet, or about one minute of latitude. The latitude of a place is determined by astronomical observations—that is, by observing the apparent position of the sun or the stars in the heavens at a particular time.

IV. The Horizon.

31. The **Horizon** is the line which appears to bound the field of vision wherever the observer may stand.

If there are no objects that intercept our view—as, for instance, on the sea—the horizon is a *circle.*

32. Horizontal directions are called **Points of the Compass.** North, East, South, and West are called the **Cardinal Points.**

Questions.—If a sphere is cut, what is the section? What is a great circle? What is a small circle? What is supposed to be drawn upon the earth's surface? For what purpose? To what two points is the location of the imaginary circles upon the earth referred? What is the equator? What are meridian circles? What is a meridian? What are parallels? How are meridians numbered? What is meant by the longitude of a place? How are parallels numbered? What is latitude? How are the degrees of longitude and latitude divided? Why are the degrees of the parallels smaller than those of the equator? What is the area of the earth? What is the length of the diameter of the equator? Of the axis? What is the circumference of the earth on the equator? What is the horizon? What is its shape? What are the cardinal points?

V. Division of the Earth into Hemispheres

33. It has been shown that every great circle divides the into hemispheres.

The equator divides the earth into the **Northern** and **Sout** Hemispheres.

34. The 20th meridian west of Greenwich divides the eartl hemispheres, one of which is called the **Eastern,** the othe **Western,** Hemisphere.

They are so called because in the one lies the great Eastern, in the otl great Western, Continent.

VI. Rotation of the Earth.—Day and Night

35. The earth *rotates* upon its axis from *west* to *east.* It pletes one rotation in a day of twenty-four hours.

The sun and stars, therefore, *appear* to move in an opposite directior *east* to *west,* or, as it is commonly expressed, "*rise in the east*" and "*set west.*" This *apparent* motion of the sun and stars is caused in reality rotation of the earth. When we travel in a railroad-car, the trees, hous other objects, also *seem* to move by us, yet it is our own motion which pr their *apparent* motion.

36. Every point on the earth's surface travels in twent hours through 360 degrees of longitude upon its parallel. A on the equator has, therefore, to traverse a greater distance i same time than points nearer the poles, and moves with a ve of 1037.5 miles per hour; a point in 40° latitude moves v velocity of only 794 miles an hour; while the velocity dimi to nothing at the poles.

37. The earth receives *heat* and *light* from the *sun.* Sinc earth is a sphere, no more than one-half of it is illuminated l rays of the sun at any given time, and this illumination is *day;* while the other half is dark, or, in other words, is in in *night.*

The illuminated and dark sides of the earth are separated great circle which is called the *great circle of illumination.*

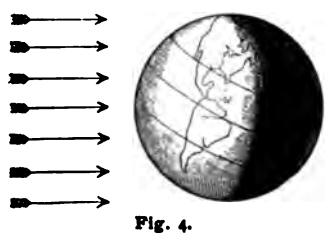


Fig. 4.

In Fig. 4 the arrows indicate the di of the sun's rays. The great circle of nation is also shown.

38. The eastern half of the hemisphere has afternoon, and is taking place at its eastern along the great circle of illumir The western half of the illuminated hemisphere has morning sunrise along its western edge.

All great circles on a sphere bisect one another. The great circle of ill tion cuts the equator into equal parts. One-half of the equator is in th and the other half is in the darkness; therefore the days and nights at th tor are of equal length throughout the year. The parallels are small circl may or may not be cut into equal parts by the great circle of illumination; in all latitudes, except at the equator, the days and the nights are of u lengths in summer and in winter.

Questions.—Which great circle divides the earth into a Northern and a Souther isphere? Which into an Eastern and a Western? In what direction does the earth In what time does it complete one rotation? Does the earth seem to us to move? is the velocity at the equator? How much of the earth receives light from the su time? What circle separates the illuminated and dark sides of the earth?

VII. Revolution of the Earth around the Sun.—The Seasons.

39. Besides rotating upon its axis, the earth has another movement. It travels around the sun upon its orbit. This movement is called its **Annual,** or **Orbital, Revolution.**

40. The earth completes one revolution in a year, which is divided according to the calendar into 365 days of 24 hours each. More accurately a year has 365 days, 5 hours, 48 minutes, and 48 seconds. This difference led to the institution of leap year.

41. The length of the orbit is 598,000,000 miles. The earth moves, therefore, through space with a velocity of more than 68,000 miles in an hour, or nearly 20 miles in a second.

42. The change of seasons is caused by the following two facts:

(*a*) By the fact that the earth's axis inclines to the plane of the orbit at an angle of about 66½ degrees.

(*b*) By the fact that the earth's axis preserves the same direction throughout the year. Hence the north pole always points to the same place in the heavens—the north star—and the different positions which the earth's axis occupies in the course of a year are parallel to one another.

If the earth's axis stood perpendicularly upon the orbit, the great circle of illumination would always coincide with the meridians and pass through the poles. In that case days and nights would be of the same length at all points of the earth. The sun would send its rays perpendicularly upon the equator, and an observer stationed at either one of the poles would see the sun moving steadily around the horizon day after day. *There would be no change of seasons.*

43. The apparent path of the sun—or, more strictly, that great circle of the imaginary celestial sphere by which the earth appears to be surrounded—which coincides with the plane of the earth's orbit is called the **Ecliptic.**

It forms an angle of 23½ degrees with the equator, and one-half of the equator is always above, the other half below, the ecliptic.

44. In Fig. 5 the equator and ecliptic are shown in their relative positions. The orbit passes through the ecliptic, and the earth's axis is inclined to the orbit.

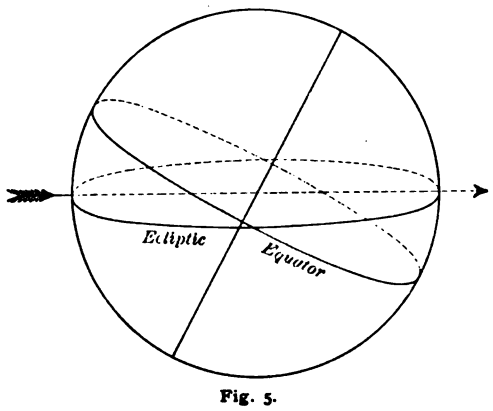


Fig. 5.

45. By observing the effect which this inclination of the earth's axis to its orbit produces at different points in its course around the sun, the changes of the seasons become apparent.

In Fig. 6 the earth is represented in the four decisive positions which it successively occupies in the course of a year.

(*a*) On the 21st of June the earth stands at A. The north pole is somewhat turned toward the sun. In this position the Northern Hemisphere has summer, and the Southern has winter. The days in the former are longer than the nights. Upon the region around the north pole, where the parallels are at that time entirely within the illuminated hemisphere, the sun does not set at all, but remains above the horizon even at midnight.

(*b*) Three months later—that is, on the 22d of September—the earth stands at B. The great circle of illumination passes through the poles and coincides with the meridians. Days and nights all over the earth are of equal length, each of twelve hours. At the south pole the sun begins gradually to ascend above the horizon and the long summer day of six months commences, and at the north pole it as gradually sinks below the horizon and ushers in the equally long winter night. The Northern Hemisphere has fall; the Southern, spring.

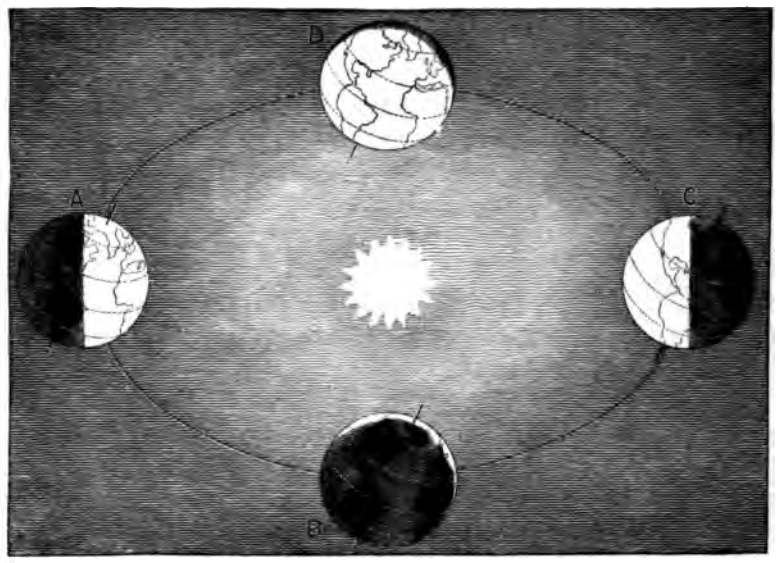


Fig. 6.

(*c*) Three months later—on the 21st of December—the earth has traversed one-half its orbit, and stands at C. The north pole is turned away from the sun. The Northern Hemisphere has winter; the Southern, summer. Around the north pole the sun does not rise at all above the horizon.

(*d*) On the 21st of March the earth has traversed three-quarters of its orbit, and stands at D. The great circle of illumination again touches both poles, and the nights and the days are of equal length in all latitudes. At the south pole the long night, and at the north pole the long day, now begin. The Northern Hemisphere has spring; the Southern, fall.

Three months later the earth stands again at A. It has traversed its entire orbit, and one year has passed.

46. The positions of the earth at A and C are called the **Solstices** (summer and winter solstice); at B and D, the equinoctial points, or **Equinoxes** (fall and spring equinox).

As the orbit of the earth is not a true circle, but an ellipse, it follows that at some time during the annual revolution the earth must approach nearer to the sun than at other times. The date of this nearest approach is about January 1, and six months later the earth is farthest removed from the sun. When nearest to the sun, the earth is said to be in **Perihelion;** when at the greatest distance from it, in **Aphelion.** While in perihelion the earth's motion is more rapid than at any other time. This makes the summers longer and cooler and the winters shorter and warmer in the Northern, than in the Southern, Hemisphere.

Questions.—What is the revolution of the earth? In what time does the earth complete one revolution? How does the earth's axis stand upon the orbit? What is produced thereby? What is the ecliptic? What angle does it form with the equator? How does the earth's axis stand in regard to the sun when the Northern Hemisphere has summer? Describe the position of the earth when the Northern Hemisphere has fall. When it has winter. When it has spring. On what day does the earth stand in the summer solstice? In the winter solstice? In the fall equinox? In the spring equinox?

VIII. Length of Days and Nights.

47. The preceding sections explain the following facts:

(*a*) On the equator the duration of days and nights is equal—twelve hours each.

(*b*) At the poles there are during the year but one day, of six months' duration, and one night, of the same length.

(*c*) The number of hours during which the sun is above the horizon in a year is the same upon the equator, at the poles, or upon any other point of the earth's surface, but the hours of daylight are differently distributed.

(*d*) During the *summer* solstice the *days* are longest; during the *winter* solstice the *nights* are longest.

This in part explains the fact that the summer is warmer than the winter; for in summer the sun is more hours above the horizon than in winter, and hence the parts of the earth that have summer receive a greater amount of heat.

48. The duration of the longest day (from sunrise till sunset) increases as we proceed from the equator to the poles, as the following table shows:

Longest day at the equator (0° lat.) lasts				12	hours.
"	"	in	8° 34′ lat.	" 12½	"
"	"	"	41° 24′ "	" 15	"
"	"	"	58° 28′ "	" 18	"
"	"	"	63° 23′ "	" 20	"
"	"	"	66° 32′ "	" 24	"
"	"	"	67° 19′ "	" 1	month.
"	"	"	73° 5′ "	" 3	months.
"	"	"	90° — "	" 6	"

There are several other motions of the earth described by astronomers. They are slight compared with the two already considered, and their cycles are in very long periods. Some of them are believed to have had a great influence in producing certain geographical and geological changes that have occurred on the earth.

IX. Zones.

49. Among the *parallels* there are *four*—called **Climatic Circles**—that are of special importance.

50. The **Tropics** (or **Tropical Circles**) are the two parallels of 23½ degrees latitude that pass through the most northerly and southerly points of the ecliptic, as shown in Fig. 7 (*cd* and *ef* are the tropics).

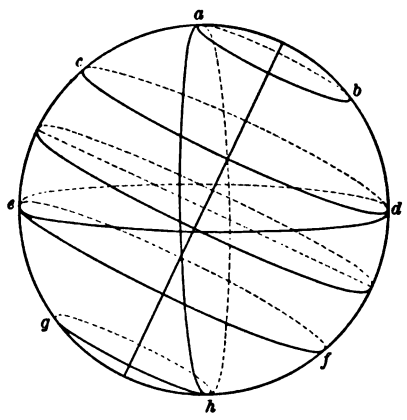


Fig. 7.

51. The *Tropic of Cancer* (*cd*) is in the Northern, the *Tropic of Capricorn* (*ef*) in the Southern, Hemisphere.

52. The **Polar Circles** are the two parallels of 66½ degrees latitude which respectively pass through the northern and southern extremities of the great circle of illumination when the earth is in the winter or the summer solstice. They are 23½ degrees distant from the poles.

53. The North Polar Circle is usually called the *Arctic Circle*; the South Polar Circle, the *Antarctic Circle* (*ab* and *gh*).

54. The *belts* of the earth's surface, bounded by the tropics and polar circles, are called **Zones.**

55. In each hemisphere there are three zones:

(*a*) The **Tropical, or Torrid, Zone,** between the tropics. In this zone the sun passes directly overhead twice each year.

(*b*) The **Temperate Zones,** between the tropics and the polar circles.

(*c*) The **Frigid, or Polar, Zones,** between the polar circles and the poles.

Questions.—What is the length of days and nights at the equator? At the poles? Which four parallels are of special importance? Describe the location of the tropics. Of the polar circles. What belts are called zones? How many zones are there in each hemisphere? Where is the Tropical Zone? The Temperate Zone? The Frigid Zone?

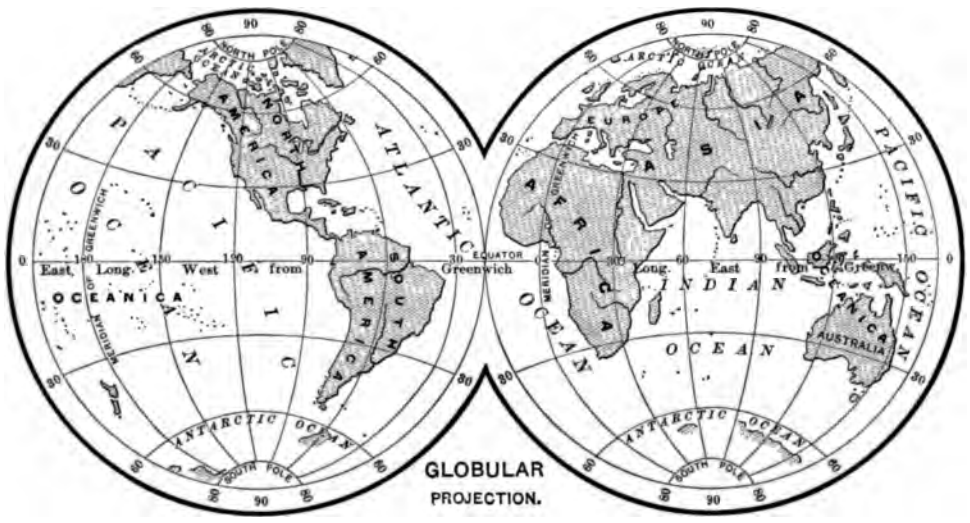


Fig. 8.

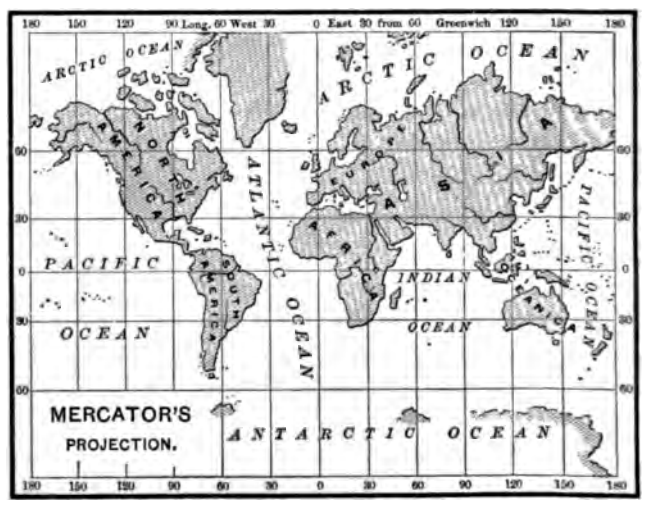


Fig. 9.

Maps and Projections.

Maps are representations of portions of the earth's surface; but if a map be made to show any considerable portion, it must always distort some of the features. The curved surface of the earth cannot be shown on a flat map without distorting the relative sizes or the directions of the places.

The mathematical method of map-drawing is called **Map Projection.** There are four kinds of map projections in common use. In three of these projections some of the meridians or parallels are represented by curved lines and the relative sizes of the countries are approximately correct, but the directions are distorted. In the fourth—called **Mercator's Projection**—the directions are correct, but the size of the countries is distorted, the relative size of those portions of the surface situated near the poles being much increased. This projection is, however, more used than any other in Physical Geography, because any given direction is a straight line on the map. For this reason it is also employed for all sea-charts in use by navigators.

CHEMICAL AND GEOLOGICAL HISTORY OF THE EARTH.

I. Chemical Composition of the Earth.

1. The earth and all things in it and on it, the sun, moon, and stars also, are composed of about seventy simple substances, or **Elements.**

A simple substance, or element, is one that cannot be separated into component parts. The elements combine with one another according to definite laws, forming a vast number of compounds. The science relating to this subject is called Chemistry.

2. Most of these elements are never found pure in nature, but occur in combination with one another. A few, however, such as gold, silver, copper, oxygen, etc., are found sometimes uncombined and sometimes in combination.

All the forms of ordinary matter which are familiar to us are only simple or complex combinations of a few elementary substances. The history of their growth is not unlike that of some of the noted works of man in which a comparatively small number of fundamental substances, such as wood, stone, iron, glass, etc., have been combined in a complete structure.

Nature is continually building, and Chemistry is one of her most able artisans. If a piece of iron be left long enough exposed to the action of the air and dampness, it becomes a mass of rust. This rust is a new substance formed from the element iron and another element called oxygen. As compound substances decay, their elements are not lost. They are merely set free, or enter into new combinations.

3. Fourteen of these elements make up the great bulk of the solid earth, its waters, its atmosphere, its animals, its plants, and all the other things which we see in common life. Five of these elements constitute probably more than three-fourths of the whole material of the earth.

Of the whole bulk of the globe, oxygen forms by weight at least one-third and silicon one-fourth; of that part of the earth known as the crust, these two elements form two-thirds of the entire mass.

4. Certain substances found in nature are called **Minerals.** Nearly a thousand kinds are known, the majority of which, when pure, are crystals or crystallized. A very few, of which the diamond is the most illustrious example, are made up of a single element, but the vast majority of them are chemical compounds. The various metallic ores are minerals in which the metal is combined with some other element or elements.

In the broadest sense, all the inorganic substances composing the earth are minerals. Gases and liquids, such as water and the atmosphere, are properly minerals, since they are neither animal nor vegetable.

5. Minerals mixed in various proportions constitute the **Rocks** of the globe. All of the common rocks are made up of a few minerals.

For example, granite is a rock composed of the three minerals quartz, feldspar, and mica. Syenite is composed of these same minerals, with the addition of hornblende, and the basalt rocks contain various mixtures of these minerals with many others. A very small proportion of the whole number of minerals make up the chief rocks of the globe, and some of these are so abundant and occur in such large masses that they may constitute rocks of themselves. The mineral quartz, for example, forms quartz-rock.

Questions.—What is an element? How many elements enter into the composition of the earth, the sun, and the stars? What science treats of the laws which govern the combinations of the elements of matter? When any substance decays are its elements lost? How many elements make up the great bulk of the earth? What two elements are the largest components of the earth's mass? What name is given to most of the substances found in nature? What is a rock?

II. Origin of the Earth.

6. The surface of the earth has not always appeared as it does now. There was a time when the present continents were beneath the sea, when the present mountains did not exist—when, indeed, "the earth was without form and void." At a remote period of its existence it was a melted fiery ball surrounded by a thick atmosphere of gases and vapors.

Astronomers have very generally accepted the theory of Laplace—known as the nebular hypothesis—in which it is assumed that at some period all of the matter constituting the present solar system was floating in space as a vast cloud or nebula. The mutual attraction of the various particles of this nebula would cause a tendency toward concentration at its center, and at the same time produce a rotation or whirling of the whole mass. As the particles were brought together and toward the center, heat and light would be developed; and as the rapidity of the motion increased, there would also be a tendency produced, in those portions of the mass farthest removed from the center, to fly away from it, as water is thrown off by a rapidly-revolving grindstone. In this way it is supposed that a series of rings was formed in succession, which separated from the central mass as it continued to condense. Each of these rings would continue to revolve, but, owing to various causes, would finally break up and gather into one or more fiery balls like the central mass, but much smaller. It is supposed that the planets were thus formed, and that at an early period in its history our earth was one of these molten spheres.

The sun and fixed stars are believed to be in a similar state now, while the moon—once in that condition—is now entirely cooled off, and its surface dotted with the craters of immense extinct volcanoes. There are masses of nebulous matter which may now be in the process of condensation.

7. In the course of ages this fiery ball cooled off, and a solid crust of rock formed on the surface. As the ball shrunk by cooling the crust wrinkled and cracked and was thrown into ridges and valleys. Meanwhile, the waters condensed and ran into the hollows. The interior is still hot, but the crust is now so thick that but little of the interior heat escapes. The present heat of the surface is derived almost entirely from the sun.

That the earth was once melted and that the interior is still intensely hot may be shown by several distinct facts:

(*a*) Its spheroidal shape is just such as would be taken by a whirling melted mass having the motions of the earth.

(*b*) The lower rocks are crystalline and of the kind which assume their character by cooling from a melted state.

(*c*) A warm and more uniform climate once existed over the whole earth. Remains of vegetation are found in Spitzbergen, Greenland, and other cold countries, of kinds similar to those now growing in warm regions.

(*d*) Volcanoes and hot springs tell of a heated interior.

The immediate surface becomes warmer in summer and cooler in winter; but if we descend a few feet, we reach a point where the temperature is uniform throughout the year and of the mean or average temperature of the place. If we descend still lower, the temperature steadily rises. This is true of all places yet observed, in all the deep mines of the world, and in all the deepest artesian wells. In fact, it has been clearly demonstrated that although the increase in temperature may vary in different parts of the globe, yet at almost any-point jets of warm water may be obtained by boring artesian wells to a sufficient depth. In the deep silver-mines at Virginia City, Nev., a temperature of over 130° Fahr. has been reached. In the artesian well at Grenelle, near Paris, a temperature of 85° Fahr. is reached at less than 2000 feet. At Neusalzwerk, in Germany, the temperature is 91° Fahr. 2200 feet below the surface. At Schladerbach, in Germany, at the depth of 4565 feet the thermometer registers 120° Fahr., and in several places in Europe deep wells have been bored to obtain hot water for heating purposes.

The ratio of increase of temperature differs in different places—from 1° Fahr. in less than 30 feet descent in some localities to the same amount in nearly 200 feet in others. As a rule, however, the temperature increases at the rate of 1° to every 50 or 60 feet of descent.

8. The name **Crust of the Earth** came to be used when it was supposed that the interior of the earth was still melted and fluid and the solid part a mere shell on the outside. It was supposed that this shell was no thicker in proportion to the fluid interior than is the shell of an egg to its fluid contents. The name *crust* is still retained to designate the outer portion of the earth because of its convenience, but most scientists now reject the belief that the whole interior is fluid.

The thickness of the crust and the actual state of the interior are matters of conjecture. It has been calculated that if the heat constantly and regularly increases, in the latitude of New York, at the rate of 1° Fahr. to every 50 feet of descent below the surface, at about 8000 feet it would be sufficient to boil water; at about 28 miles the temperature would reach 3000° Fahr. and there would be heat enough to melt iron, and at much less than 100 miles there would be sufficient heat to melt any known substance.

But under such great pressures as exist deep down in the earth melting-points are not the same as at the surface, and there is much difference of opinion as to whether the interior is solid and rigid, or viscous, or fluid in places. All agree as to the intense heat. The difference of opinion exists as to the degree of solidity.

Questions.—What was the condition of the earth in the most remote period of its existence? What theory is generally accepted as giving a history of the formation and growth of the solar system? Are all the members of the solar system now in the same condition? What happened as the earth cooled? Does very much heat now escape from the interior through the crust? From what source is the heat of the surface now chiefly obtained? What proofs can be given of the fact that the earth was once melted and that the interior is still hot? Is the temperature of the earth very variable at a point a little below the surface? Does the temperature change if we descend considerably below the surface? In what way? What is about the average ratio of change? At about what depth would the boiling-point of water be reached? For what purpose have some of the artesian wells been bored? What is meant by the crust of the earth?

Standing Rocks in the Grand Cañon District, showing the Stratified Condition of the Rocks.

III. Varieties of Rocks, and their Conditions.

9. There are many kinds of rocks, and they have been classified in various ways, according to the characteristics upon which the classification was founded. For the purposes of the geographer they may be divided into two principal classes, the **Stratified** and the **Unstratified** rocks, with an intermediate class called **Metamorphic** rocks.

10. **Stratified Rocks** are those which are made up of a series of *layers*, or *strata*.

These strata were slowly deposited in various ways, and were subjected to the numerous processes of nature until they became parts of the solid rocks. When rivers, or the atmosphere, or any other agencies, remove a part of such rocks, the remaining portions thus exposed exhibit the different layers.

The accompanying picture represents rocks which have been left standing in this way, in what is known as the Grand Cañon District, in the north-western part of Arizona. The successive strata are clearly marked.

All stratified rocks were made up originally of fragments, sand, or fine particles of mud carried by water or dust driven by the wind; hence strata in their original positions are horizontal, or very nearly so.

There are three general classes of stratified rocks—the sandstones and conglomerates, consisting mostly of quartz; the slates and shales, which have been formed from deposited clays and fine mud; and the limestones.

The conglomerates—or, as they are often called, "pudding-stones"—consist of pebbles of various sizes cemented together by sand or clay. The pebbles were probably bits of rock broken off and ground smooth by glaciers. Then becoming imbedded in the mass of ice they were carried out to sea, and, as the glacier or iceberg melted, they were dropped to the bottom, where they mingled with sand and mud. As the ages rolled on, this mixture was covered by other materials, and the great pressure of the masses above, in connection with the heat below, pressed and baked it into solid rock, just as bricks are pressed and baked artificially.

The sandstones cover a more extensive area than the conglomerates, and were formed by the deposit of sand along the banks of rivers and on the sea-shore. The layers thus built up were also subjected to the action of heat and pressure.

The clay or mud stones are even more widely distributed than the sandstones, and, like the conglomerates, were originally formed at the bottom of the sea. It is estimated that the time necessary for the accumulation of enough mud to make a layer of slate of the thickness of ordinary roofing-slate would be scarcely less than a century, and, as beds of slate are frequently over a thousand feet thick, some idea may be gained of the length of time required by nature to build the rocks.

The limestones, also, are formed beneath the surface of the sea, and consist of the skeletons and shells of sea-animals, sometimes mixed with mud, and forced together by pressure. Such deposits are constantly forming, even at present. Large rivers carry out to sea sand and other materials, which sink to the bottom and form banks or low islands. The accretions along the sea-shores are in part results of the action of the sea.

As the stratified rocks were built up by the continuous formation of horizontal layers, only the surface-layers would be known to us unless others were exposed to view by some natural cause. The deepest mines penetrate but an insignificant fraction of the distance from the surface toward the center of the earth.

The process of mountain-building has made it possible to study the upturned edges of stratified rocks which were once buried thousands of feet under the earth. As the earth has been constantly losing its heat, and as the space outside of the earth is very cold, it is only natural that those portions nearest the surface should first become solid. The loss of internal heat also produced a shrinkage, and as the outer crust became too solid to shrink, it was at certain places forced into elevations, which are known as mountains.

This uplifting of mountains has produced changes in the original horizontal position of the strata. In some cases they have been tilted out of their first position, and thus exposed to the light of day. In the diagram (fig. 1) a section of tilted rock of this character is represented.

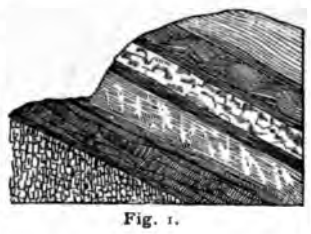


Fig. 1.

In other cases the strata have been raised into *folds*, or crumpled up into groups of irregular flexures, one fold succeeding another, till they resemble a series of wrinkles—and necessarily coarse wrinkles—on the earth's surface. Often the strata break, and the broken edges are upturned and brought to the surface. In fact, mountain-chains are generally formed by these foldings and breakings of the strata.

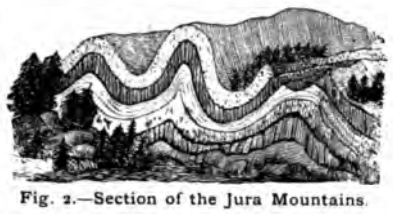


Fig. 2.—Section of the Jura Mountains.

Each mountain-region presents examples of these flexures and uplifts. (See figures 2 and 3.)

Fig. 3.—Section of the Appalachian Mountains.

As a consequence of the tilting or folding of strata, deposits are often laid down upon the upturned edges of older rocks.

In the accompanying figure the strata from *a* to *b* are tilted and folded by an uplift, and the strata *cd* are lying upon them.

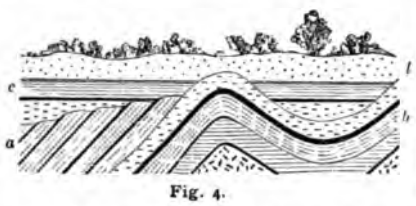


Fig. 4.

It is obvious that where cases of this description occur they indicate the relative ages of the rocks. The lower rocks must have been completely formed before they were uplifted, and they must have been upturned and folded before the overlying beds could be deposited. We see here the evidence of three successive periods—first, the period of forming the lower rocks; secondly, that of uplifting and folding them; and thirdly, that of forming the upper rocks.

As the earth's crust consists in all regions of many rock-formations overlying one another, it is evident that the earth, from the time of the formation of a solid crust until the present, must have passed through many successive changes.

11. **Unstratified Rocks** are those which at the present time do not appear in a stratified condition. Some of these were melted when they came up from great depths and broke through fissures, and hence they are called *igneous* rocks. They occur on various parts of the earth's surface, but especially along mountainous and hilly border-regions.

Fig. 5.—Giants' Causeway.

Some unstratified rocks split into regular columns as they solidify from the melted state. The basaltic columns of Fingal's Cave, on the coast of Scotland, and the Giants' Causeway, on the Irish coast, are noted examples.

More frequently these rocks are massive and break into irregular blocks, as is the case with the Palisades on the Hudson River, and with granite.

12. Not only are stratified rocks often bent and broken by the forces working from beneath them, but their character is also often changed by heat, by steam, by pressure, and by other agencies. They are then called **Metamorphic Rocks.** Such rocks are found in nearly all mountainous countries, and in many hilly regions. They are of a great variety of kinds, and are intermediate in character between the stratified and unstratified rocks, ranging all the way from those which are scarcely changed at all to those which closely resemble igneous rocks.

Questions.—Into what general classes may rocks be divided? What are stratified rocks? How were they formed? Name the varieties of stratified rocks. Describe the process of formation of these different rocks. Are these strata visible at the surface of the earth? How is information concerning stratified rocks obtained? Describe the changes that sometimes occur in the original position of the strata. What do the rocks teach concerning changes which have taken place in our globe? What are unstratified rocks? What are igneous rocks? What are metamorphic rocks?

IV. History of the Strata.

13. The surface of the earth has been constantly changing. As soon as the waters were gathered together into seas and the dry land appeared, the land began to crumble and to be washed back again into the sea, where it was distributed over the bottom in layers or beds of mud or sand, forming strata. These afterward hardened and thus the stratified rocks were made. This process is still going on. The weather disintegrates rocks and soil, the rains wash down the finer particles into the streams, which carry them to the lakes or seas, filling them up and adding to their shores.

14. As the heated interior of the globe cooled and shrunk, the harder crust of the rock bent and wrinkled. The strata which were at first nearly level were tilted up at various angles and were afterward broken, the surface rising in some places and sinking in others. These motions of the crust and variations of the level have changed the shapes of the land-masses and of the oceans from age to age, but the land has ever been washing back again into the sea, and the formation of stratified rocks has gone on continuously ever since there were lands to wash down and seas or lakes to be filled.

The most familiar instances of this fact occur at the mouths of great rivers like the Mississippi, Ganges, Nile, or Hoang-Ho. The mud brought down by the rivers, and deposited in the sea about the mouth, has formed many thousands of square miles of land and constituted some of the most fertile and densely-populated portions of the earth. (See paragraph 20, p. 48.)

15. As the strata were being formed, some of the plants and animals which then lived sunk in the sea or in the marshes and were buried in the mud at the bottom, and were thus in a measure preserved. These remains of animals and plants are called **Fossils.**

Sometimes fossils consist of the bones, teeth, shells, or other hard parts of the original creatures, but little changed in appearance or composition, but more often they have been changed into stone, or *petrified*. As the original substance decayed, mineral matter entered the body as fast as the organic matter escaped, thus gradually substituting a stony counterfeit of the living original.

Sometimes the organism entirely decayed, leaving a cavity like a mould, which later was filled with mud or sand, and thus a fossil was made which is a mere cast of the original.

Sometimes a part of the actual material is left, but so changed in appearance that its origin is not easily seen. The impressions of fern-leaves or the stems of club-mosses are sometimes found in coal, but very often they have lost all appearance of vegetation; and yet they are true specimens of fossil vegetation. So, too, amber is a fossil resin found in the sands of the Black Sea.

Sometimes animals or birds, wading in shallow water or on the shore recently covered with water, made tracks in the soft mud; these were soon covered with fresh layers, and so have been preserved. In the quarries at Greenfield, Mass., Portland, Conn., and Carson, Nev., and at numerous other places, many tracks are found preserved with wonderful distinctness in the hard building-stones. Some of these tracks are small enough to have been made by insects, others large enough to have been made by elephants.

Slab of Stone, showing Fossil Foot-prints.

Even the impressions of rain-drops, made ages ago in soft mud, are preserved in stone with such delicacy that the direction of the wind at the time of the shower is shown. The term *fossil* includes all these various remains.

16. The study of fossils belongs to that branch of geology called **Palæontology.** Many thousands of fossil species have been described. The most of them are of kinds which no longer live on the earth, but they so resemble living species, and are so related to them, that they are classified with them. From the character of the fossils, it is possible to infer what was the condition of the earth when the creatures lived.

17. Any one kind of plant or animal taken as a whole constitutes a **Species.**

The individuals of a species resemble one another more closely than they do the individuals of any other species, and they transmit their especial and distinctive characteristics to their descendants from generation to generation.

Naturalists are not entirely agreed among themselves as to the exact definition of a *species*, nor are they always agreed as to whether some particular kind of creature is a species of itself, or only one of several varieties which, all together, make up the species. But all use the term, and all are agreed as to the general idea of distinct species. This idea lies at the very foundation of the study of Natural History, and the species is the *unit of classification* in all systems of Botany and Zoology. Moreover, all naturalists are agreed that different species came into existence at different periods of the earth's history, and that many have passed away and no longer exist except as fossils. We call all such *extinct* species, while all now alive on earth are *living* species.

There are perhaps a million living species of plants and animals. Several hundred thousand have been described by naturalists, each one differing enough from all others to be recognized as a distinct kind.

Some species are found living only in some one place; others are widely spread over the globe. Some are rare; others exist in countless millions of individuals. Some are so small that they can be seen only with a microscope; others are of great size, like the gigantic elephant and whale among animals, and the largest trees in the vegetable world. They differ also in structure. There are many species which consist of a single microscopic cell, and there are countless gradations between these and the highest orders of animals and plants.

Naturalists have devised schemes of classification by means of which every creature, living or extinct, may be so classified that its relations to all other creatures may be seen. In such schemes, species that are most alike are grouped together into **Genera**; genera which resemble one another into **Families**; families into **Orders,** and these into **Classes,** etc., according to their resemblances and differences. The term **Type** is used for a group of species having certain important characteristics in common.

18. Animals are higher or lower in the scale of being, according as their structure and character are more or less complete and complicated. The fewer the organs and the simpler the structure, the lower (as a rule) the animal stands in the scale; on the contrary, the more varied and complete the structure, the higher the creature.

For example, the horse is called one of the higher animals because it has organs for a variety of uses, senses like ours, and some degree of intelligence. Monkeys and apes are still higher because they have a greater variety of organs and greater intelligence. On the other hand, a reptile is a lower animal than the horse, and an oyster or polyp is still lower in the scale of being, having fewer special organs, its senses less complete—some of them, it may be, wanting—and its intelligence nothing more than the exercise of the simplest instincts.

The same thing is true of plants. The rose and magnolia belong to the higher orders: they have roots, stems, branches, leaves, flowers, and fruit, each consisting of several parts. Ferns, mosses, and the like are much lower in the scale: they have no flowers and do not produce true seeds. The seaweeds are still lower: they have no distinction of root, stem, or leaf. The stem may play the part of a leaf in the economy of the plant. So it is possible to descend until the lowest plants as well as the lowest animals are reached, consisting of but a single microscopic cell without separate organs.

19. The stratified rocks having been formed in regular succession, and containing, as they do, fossil remains of the creatures that lived upon the globe while the strata were forming, it follows that these strata and their fossils furnish a continuous history of the earth and its inhabitants. The study of this history belongs to **Geology.**

20. The very lowest fossil-bearing strata contain the fossils of only very low orders of creatures, and the number of species is comparatively small. Following the strata upward, there is proof of a gradual appearance on the globe of higher and higher kinds, and a greater and greater variety of life.

The plants and animals of the globe have changed as the earth itself has become better and better fitted for the existence of higher and higher kinds. *The succession of life on the globe has followed a grand law of Progress.*

21. Taking the earth as a whole, the formation of the strata has gone on continuously, but in any one country its progress has been irregular. The study of the geology of any country shows that there have been local disturbances and interruptions, forming breaks or intervals between strata. There is no place known on the earth where one may find a complete and unbroken series of strata, with their fossils, from the bottom to the top of the series.

The strata consist of sandstones, conglomerates, limestones, slates, etc., variously alternating. Often strata very unlike in character and with very different fossils lie one immediately above another. Local changes of level while the rocks were forming have made breaks in the succession of life. This is especially true of Europe, where the science of Geology had its birth and early growth, and where names were first applied to the different periods of time during which the formation of the strata was in progress.

22. The terms **Era, Age, Period, Time,** etc., have been variously used by geologists to designate the portions of time when particular strata were laid; while the terms **Groups, Systems, Series,** etc., have been applied to the strata themselves. Early writers used these terms somewhat indiscriminately, but now each of them has come to have a tolerably definite meaning.

Questions.—Is the formation of stratified rocks a continuous process? What name is given to the remains of plants or animals which are preserved in the strata? Of what do these remains consist? To what science does the study of fossils belong? What is meant by a species? How are species grouped? What makes an animal or a plant high or low in the scale of being? Of what does Geology treat? What may be said of the law of progress in the development of life?

V. Geological Eras.

23. The strata are named with reference to their fossils. They are all arranged in four great groups, representing four grand divisions, or **Eras,** of time in the earth's history. Each *era* is subdivided into **Ages.**

These terms are used in Geology just as they are in the history of the human race; as, for example, when we speak of the "Middle Ages" as a part of the "Christian Era."

No one kind of rock makes up the strata of any particular age or era. Sandstones, limestones, slates, etc., are found among the rocks of all ages. The strata are classified according to the fossils which they contain, and not according to the varieties of rock of which they are composed.

In this connection, it must be remembered that the molten material of eruptive rocks may flow over a country in sheets or beds, and thus in a sense be stratified; but, in Geology, such eruptive rocks and lavas are not classified as stratified rocks: they may belong to any age or any era.

24. The **Archæan Era** is that in which the earlier strata were formed. The term Archæan means *ancient.* The rocks of this group are more difficult to study than those of any other group, and have been variously subdivided, but the most common subdivision represents two geological ages.

The **Azoic Age** includes all those lower strata in which no geologist claims that fossils have been found. The term Azoic means *without life.*

The **Eozoic Age** includes the strata in which exist certain appearances which some geologists believe to be imperfectly preserved fossils of very low forms of life. Other geologists, however, believe them to be of strictly mineral origin, and not the remains of organisms. One of these uncertain appearances, called the *Eozoon* (Eozoon meaning *dawn of life*), gives the name to this age.

The rocks belonging to the Archæan Era are mostly crystalline and highly metamorphic. They have an enormous thickness, and are usually much bent, and often broken; and if they ever contained fossils, these have been either destroyed or so changed that scientists are not agreed as to whether the rocks contain actual fossils or not.

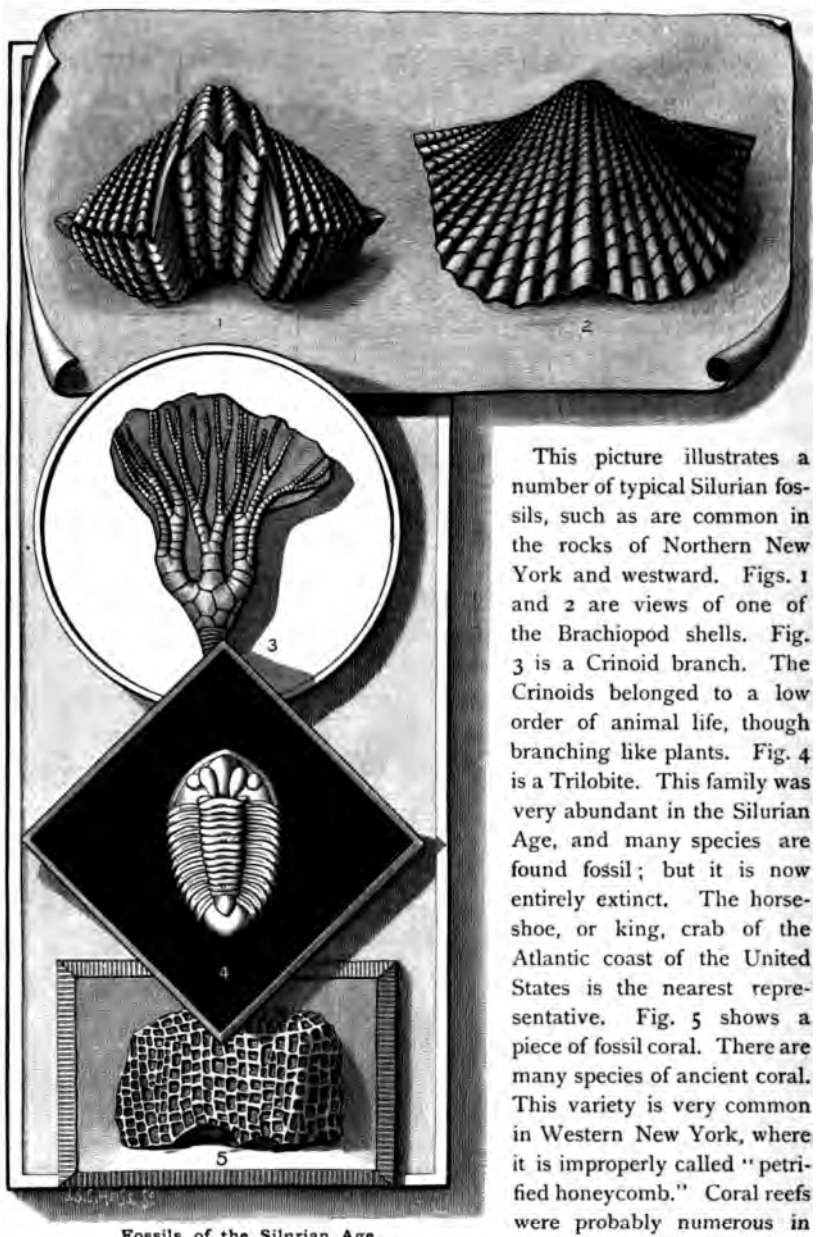
Most of the present dry land of the earth has risen from beneath the sea since the rocks of this era were deposited. The strata of this formation in North America occur most largely about Lake Superior and in Canada. The hills and mountains which are composed of Archæan rocks are rounded by the denudation they have undergone in the immensely long period since they appeared above the sea. The newer Rocky Mountains and Alps are sharper. (See paragraph 37, p. 18.)

25. The **Palæozoic Era** follows next. Palæozoic means *ancient life*, and the era is divided into three ages.

The **Silurian Age,** or **Age of Invertebrates,** during which only the lower kinds of creatures lived, is the first of the three ages. Most of the fossils are the shells of *mollusks* and *crustaceans*, or the remains of corals and other animals of low type. The fossils seem to indicate that the conditions of climate, etc., were the same over nearly the whole of the globe. There were comparatively few species; all were of low types, and some of them were widely spread over the earth.

No vertebrate animals—that is, animals having a backbone, such as the mammals that live on the land, or the reptiles that dwell on the land or in the water, or the fishes of the sea—existed in this age. It is probable that there was no life on the land unless of the lowest forms of vegetation; and it is not likely that there were any extensive areas of land resembling in size the present continents, but rather that the sea was filled with islands which formed the nuclei of the present land-masses.

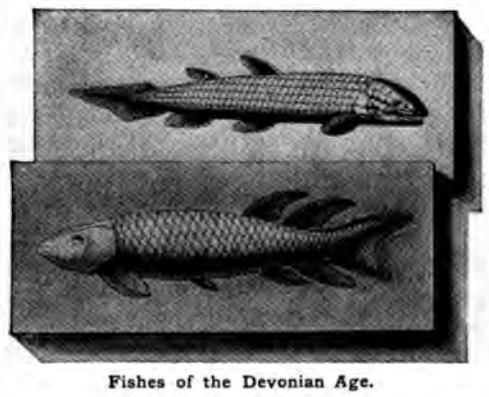
Although the life at this time was of a low order, yet it was progressive in character; and the way was prepared for higher kinds of creatures.



Fossils of the Silurian Age.

This picture illustrates a number of typical Silurian fossils, such as are common in the rocks of Northern New York and westward. Figs. 1 and 2 are views of one of the Brachiopod shells. Fig. 3 is a Crinoid branch. The Crinoids belonged to a low order of animal life, though branching like plants. Fig. 4 is a Trilobite. This family was very abundant in the Silurian Age, and many species are found fossil; but it is now entirely extinct. The horseshoe, or king, crab of the Atlantic coast of the United States is the nearest representative. Fig. 5 shows a piece of fossil coral. There are many species of ancient coral. This variety is very common in Western New York, where it is improperly called "petrified honeycomb." Coral reefs were probably numerous in the Silurian seas.

The **Devonian Age,** or **Age of Fishes,** is notable on account of the fact that fishes increased in numbers, in kinds, and in perfection of development, and became the dominant type of animal life. The corals, crinoids, trilobites, and other types which were characteristic of the Silurian Age, were also abundant in the Devonian Age.



Fishes of the Devonian Age.

The animal life of this period was almost completely confined to the waters of the sea. None of the higher types of land-animals had as yet made their appearance, though a few varieties of insects similar in structure to the dragon-fly have left their traces in the strata. Most of the fossils of the Silurian and Devonian ages are, however, the shells or other hard parts of the animal.

What vegetable life then existed was in all probability principally in the form of sea-weeds, and, although it seems likely that ferns, ground pines, and some small trees may have flourished quite extensively in the Devonian Age, all plants were of such low character and so soft in structure that they have left but few and uncertain traces in the rocks.

The **Carboniferous Age,** or **Age of Coal,** is the last of the three divisions. During this period some insects and reptiles appeared; but the remarkable feature was a rank growth of low orders of vegetation, when ferns and club mosses grew as trees. Coal is principally composed of the remains of vegetation belonging to this age.

The Carboniferous Age.

The climate was probably warm and very damp, and the atmosphere charged with carbonic acid. The air was partially purified by the rank vegetation in the great swamps. The remains of this vegetation accumulated in a partly decayed state, as peat does now in bogs. This material was afterward compressed and hardened into coal under the weight of the strata which were deposited over it. Where the beds of coal have lain undisturbed, the coal when ignited burns with flame and black smoke, and is called *bituminous* coal. Where the beds have been bent, folded, and upheaved in the mountains, and probably somewhat heated, the volatile part has been driven off, and the hard coal which is left is called *anthracite*.

The Era of Reptiles.

26. The **Mesozoic Era** (Mesozoic meaning *middle life*) follows next, and is also divided into three ages, the **Triassic,** the **Jurassic,** and the **Cretaceous,** during all of which reptiles, and more especially **Saurians** (lizard-like creatures), were the dominant animals.

A great number of Mesozoic reptiles have been described, some of them of strange forms when contrasted with anything now alive, and some of gigantic size. The *Ichthyosauri* swam in the waters. The larger species were thirty feet long. They had short necks, strong jaws, and gigantic eyes, which were sometimes nearly a foot in diameter. The *Plesiosauri* also lived in the water. They had small heads and long snake-like necks. The *Atlantosaurus* was sometimes over a hundred feet long and thirty feet high. Some of the larger reptiles had an armor of hard scales a foot or more wide, and had spines, a foot or two long, on their backs.

The *Pterodactyls* were flying reptiles with slender jaws and bat-like wings. The larger species had a spread of wings of twenty-five feet, while the smaller were scarcely as large as pigeons.

The skeletons of some of the Mesozoic reptiles have several of the features now found in the skeletons of birds. During this era birds appeared on the earth, a few of the species having certain of the characteristics of reptiles. The *Archæopteryx*, in Europe, had a long jointed tail with a row of feathers down each side, and the *Ichthyornis*, found in the strata of Kansas, was a bird which had a backbone like that of a fish, and a row of teeth in each jaw.

There was a great development of forest trees during this era, and before its close a few species of small mammals appeared on the globe.

27. The **Cænozoic Era** is the last, and is still in progress. The name Cænozoic signifies *recent life*. The term **Neozoic** is used by some geologists for this era, which includes two geologic ages.

The **Tertiary Age,** or the **Age of Mammals,** is the first, during which this, the highest group of animals, increased greatly in numbers, in size, in the perfection of their development, and in importance.

In this age the continents became much as they now are, and the general aspect of nature was approaching in character that of the present time. Some species still living on the globe flourished then, and others were like existing species. The climate seems to have been more uniform than it is now. Fossils of trees and of animals found in the far north—in Greenland, Spitzbergen, Nova Zembla, New Siberia, and elsewhere—show that a mild climate and great forests extended far beyond the Arctic Circle.

These forests contained large trees much like those now found in some parts of the world. In Europe there were species of hickory, magnolia, sassafras, and various other genera which still grow in America, but which are no longer native to any part of the Old World. Species of *Sequoia* much like the redwoods and "Big Trees" of California are found fossil from Italy to Great Britain, and in Siberia and Nova Zembla as well as in Greenland and British America. In these forests lived many kinds of animals, some gigantic in size and of strange forms. Their bones are found in immense quantities in the "Bad Lands," near the Rocky Mountains, and in other places. The mammoth elephant represented in the picture belonged to the early part of the Quaternary Age.

Mammoth Elephant.

The **Quaternary Age,** or the **Age of Man,** is the one at present in progress. Most of the species now living came into existence in this age, the last and highest being **Man.** During all the previous ages the earth was being prepared for him.

It must be kept in mind that the great physical changes on the surface of the earth, and the changes in the character and kinds of living beings, have gone on together.

At first there was no life; then when the earth was ready for them low forms appeared. Next, with the changes of successive ages, higher types followed, though the lower still continued to live along with the higher. The law of progress mentioned in paragraph 20 does not imply that individuals and species became higher, but that higher and higher forms came into existence as the earth and atmosphere were gradually fitted to receive them. The lower could live without the higher, but the higher could not exist without the lower, as they were always more or less dependent upon them for food. So it has happened that each great class has had its living representatives ever since its creation. Species, like individuals, have perished, but the type has been perpetuated by the creation of a new class of beings; so that now all grades are found together, from the lowest upward to man.

Questions.—How are the strata named? What is represented by an era? Name the first era. Into what ages is it divided? Name the second era and its subdivisions. What were the chief characteristics of the Silurian Age? Which was the age of fishes? Of coal? What form of animal life is peculiarly characteristic of the third era? What names are given to the fourth era? What are the distinctive features of the Tertiary Age? What age is now in progress? What is said of the development of life?

VI. Changes Still in Progress.

28. Most of the kinds of change which have taken place in previous geological ages still continue. Their action is slower and less violent, but is still sufficient to alter the geography of the globe from generation to generation.

Some of these changes—such as the formation of deltas, the growth of coral islands, etc.—will be noticed in future pages, in connection with other phenomena to which they are closely related.

29. The wearing away by water, the furrowing of land by streams and glaciers, the disintegration of rocks and soils by the weather, and the washing down and removal of soil from higher to lower levels are the most common kinds of change now occurring, and are the most universally in operation. The process embodied in all these forms of surface variation is called **Erosion.**

Wherever there is freezing the frost pulverizes the soil and causes the rocks to crumble. Rains can then wash away the finer particles. In warm climates rocks crumble and decay by reason of the chemical action of rain-water and the gases given off by the decay of organic matter. From these various causes, the solid rocks of the earth's crust are usually covered with a soil made from disintegrated rocks.

30. Water is necessary for this pulverization and destruction. Temples and works of art which may withstand the weather for ages in a dry climate soon crumble in a moist climate like that of the Eastern United States or of Northern Europe.

The famous obelisk in Central Park, New York, is made of syenitic granite, one of the hardest and most durable of rocks. It was first set up in Egypt more than fifteen hundred years before the Christian era, and was finally brought to America in 1877. In ten years in the climate of New York, with its rains and its frosts, the obelisk crumbled more than it had done in the thirty-four centuries it had stood in the dry and warm climate of Egypt.

31. Every rain which is heavy enough to make a stream, no matter how small that stream may be, washes some of the finer matter of the soil from the higher to the lower levels.

If the soil is soft and the hill steep, a heavy shower washes out gullies or small, narrow furrows or channels. Where the stream is permanent, it finally wears out a channel to the lowest depth which it can reach. Rivers bear mud from their banks to the sea, to be deposited about the mouth or to be carried out into the water beyond. Other conditions being the same, the swifter the stream, the greater the amount of mud that will be carried. A gentle stream will carry only the finer mud; a swifter stream will carry sand also; while a mountain-torrent will roll along great rocks. These deepen the channel by wearing out the bed, and thus it happens that swift rivers in the mountains have deeper and narrower valleys than the slower rivers of the plains.

In Western America the name cañon (or canyon) is given to very narrow and deep valleys which have been worn by water-courses.

32. Where a swift stream runs over strata of rocks which lie nearly level, and some of which are harder than others, the softer strata wear away more easily, and waterfalls and cascades are formed over the harder rocks.

The famous Niagara Falls were produced in this way. A hard stratum of limestone constitutes the upper surface of the rocky bed over which the water plunges. Under this is a thick bed of soft shale, which is easily worn away, undermining the hard rock, which then breaks off and falls in great masses; and the cataract works constantly backward toward Lake Erie at the rate of three or four feet each year. In this manner it has eroded its way back, and has formed the deep gorge which extends about seven miles down the stream.

33. The waves of the sea strike upon the shores with even greater destructive force than that of a cataract. If the shore is a rocky one, the impact of the waves gradually wears away portions of the rock, thus undermining the cliffs. The overhanging portions then break off and fall, and the pieces are soon hurled against the precipitous shore, to aid further in the work of destruction.

As the broken fragments become smaller they are rolled along the sands of shelving beaches till they become mere pebbles, and eventually they are ground into minute particles, to be used again in the building up of the strata.

In many sections of the world the ocean is constantly encroaching on the land and the coast-line is undergoing continual change. An instance is recorded where, on the coast of England, the sea worked its way inland through solid cliffs to a distance of over 50 feet in the space of five years. Along sandy shores the waves, sometimes aided by the winds, are always changing the shape of the coast-line by the ceaseless shifting of the sands.

34. The formation and action of streams have already been mentioned in paragraph 31. As streams unite they produce, at first, narrow valleys. As erosion continues these valleys become wider and wider, and, as the material worn off by the water is deposited, alluvial plains are formed, which in the time of freshets are covered by floods. Through these "bottom-lands" the stream in ordinary seasons has its channel. With the progress of erosion the ridges between the valleys are worn away, until a single valley takes the place of two or more.

The study of Geology shows that when a plateau or an elevation of land has been produced by any of the processes of uplifting, the action of the rains and the streams which result from them will eventually carve out mountain-chains and valleys. Even where the original flexures, or folds, produce the outlining of mountain-ridges and valleys, the final shape of the peaks and heights has been due to erosion, and the greater part of the denudation has been brought about by the erosive action of fresh water.

The Catskills and many ridges of the Rocky Mountains are the product of the erosive action of water. The anthracite coal-fields of Pennsylvania once belonged to the bituminous region lying to the west and the southwest, but they have been separated and exposed by elevation and erosion.

The action is often very rapid. A gorge several miles long, over 50 feet deep, and in places nearly 200 feet wide, was made in a bed of rock near Milledgeville, Georgia, where twenty years before there was but an insignificant rill.

35. The capacity of water for dissolving certain minerals, and the chemical properties it acquires by carrying other reagents in solution, are also important factors in the work of erosion. As water has played the most prominent part in the transportation of material from which the rocks have been constructed, so it is now, and always has been, the chief agent in effecting their disintegration.

The processes by which water accomplishes its work of erosion are very numerous. It causes decay of the solid rocks when present merely as moisture in the atmosphere. Its destructive power is apparent in the force of impact, whether of the raindrop, of the cataract, or of the ocean-billow. It wears away the sides and the bottom of a river-channel by the abrasion, or corrasion, produced by the grinding of the transported sand, gravel, or fragments of rock. By creeping into the interstices of rock and expanding as it freezes it tears the substance apart with irresistible force, or in the form of ice-fields or glaciers it corrades and transports vast quantities of stones and rock. As a chemical agent it dissolves and removes material which, when the water evaporates, is often found deposited in new and fantastic shapes, as is illustrated in the stalactites of caves, and in the sinter-basins of the Yellowstone region and the famous terraces of New Zealand which were destroyed by the Tarawera eruption.

36. The winds have also a greater influence in producing variations of level than was formerly supposed. Along the seashore the wind drifts the dried sand beyond the reach of the tide, and thus "dunes" are formed inland. In some countries there is a kind of soil called "loess" which lacks the stratified appearance of material

deposited by water, and it is believed to owe its peculiar character to the wind. The wind is also an element in atmospheric erosion, and its work of carving and polishing solid rock is thought to be largely accomplished by means of the sand which it often carries.

The sand-hills of San Francisco and of the coast of Holland are examples of dunes, and on the deserts of Nevada there are hills of drifting sand said to be 400 or more feet high. When some storm on the coast lashes the waves to an unusual height, the sand is piled up beyond the ordinary limits of the tide. These sand-heaps soon dry when exposed to the heat of the sun, and the winds from the sea drive the sand on the seaward side of the heap or dune to the landward side, so that unless checked by land-breezes the whole sand-heap gradually moves inland. The progress of dunes is sometimes checked by the growth of vegetation.

In China the loess is of great extent and thickness, and it is also found along the banks of the Rhine and the Mississippi.

Certain of the fantastic shapes which the rocks have assumed in the Rocky Mountains and elsewhere are supposed to be the results of drifting sand. Windows along tracts of low seashore are often ground away or perforated by the wind-driven sands, and glassware is now largely ornamented by means of an artificially-propelled sandblast.

37. The facts of Geology prove that the rocky crust has for ever been unstable and always changing its level. Many sections of the continents which are now far from the seashore have been alternately raised above and submerged beneath the level of the ocean. The greatest changes of level have occurred in comparatively recent geological times.

In the coal-formations of Illinois the beds of coal are separated by layers of limestone which contain numerous marine fossils, thus proving that the land was above the sea when the Carboniferous vegetation flourished and below it when the limestone strata were deposited. As many as sixteen alternations of this kind are shown to have occurred.

The various influences just described have been at work in all the geological ages, and it is difficult to appreciate the scale upon which they have taken place. By denudation the mountains have been sculptured into the shapes which they now have. Their heights have been reduced and their details of surface formed by the various agencies of erosion. The older mountains of the earth, such as the Laurentian, are consequently lower and rounded, while the newer, such as the Rocky Mountains, the Alps, and the Himalayas, are sharper and more rugged. The grander features of mountain-systems are due to the bending and breaking of the crust, but all the details of surface are due to denudation.

38. It is obvious that the two great agencies which cause the constant change of level are the folding or wrinkling of the crust, and erosion. During the process of flexure the twisting and straining of the rocks are often so great that a break occurs, leaving one portion many feet above another. Such a break is called a **Fault.** Faults may be merely local where the strata are slightly dislocated, or they may be of vast extent. Igneous eruptions and overflows often occur along the lines of great faults, and earthquakes are frequent in such regions.

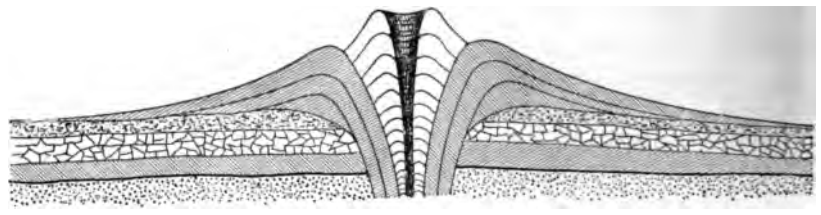
Questions.—What kinds of change are at present in progress? Are these similar to those of previous geological ages? What is the process embodying all these forms of change called? What is the most important agent in producing the disintegration of rock and soil? Describe the action of a stream in wearing away the land. What effect does a variation in the hardness of the strata have in producing waterfalls? What is the effect of sea-waves? What becomes of fragments of rock broken off by waves? Is the coast-line changed by the action of the water? How are valleys formed? What part does water play in the formation of mountains? Does water produce erosion by means of its chemical properties? What is the chief agent in causing erosion? Name some of the principal processes by which the results are attained. What effect has the wind in producing changes of level? Describe its action. What has been the character of the earth's crust through the geological ages? When did the greatest changes of level occur? How do the newer differ from the older mountain-ranges? What are the two important agencies in producing a change of level? What is a fault? What phenomena are frequently associated with faults?

VII. Volcanoes, Earthquakes, and Hot Springs.

39. **Volcanoes, Earthquakes,** and **Hot Springs** are so intimately connected that they can best be treated together. They are all produced, in one way or another, by the mutual action and reaction of the solid crust of the globe and the heated interior upon each other. Volcanoes and earthquakes are probably due in part to the crumpling and cracking of the hard crust, in its efforts to adapt itself to the shrinking and changing heated interior, while hot springs are caused by water under ground coming in contact with heated rocks, or, as in the case of many mineral springs, the water may be heated by the chemical action accompanying the solution of solid matter.

40. A **Volcano** is a hill or mountain composed of material cast out upon the surface by the heated interior and having a passage or channel through the solid crust. The opening at the surface on or near the summit of the mountain is called the **Crater.** The act of throwing out materials is called an **Eruption.**

41. The substances ejected from volcanoes are of great variety. The most common substance is melted rock, called **Lava,** but this is usually accompanied by fragments of rock not hot enough to be melted, and called by a variety of names, according to its character and appearance. When pulverized very fine, it is called *volcanic dust* or *ashes.* Large fragments are called *cinders* and *scoriæ. Volcanic bombs* are rounded masses, and are often thrown to a great distance. *Pumice* is a porous, spongy material produced by the ebullition of gas or steam through the melted rock while cooling. It is usually so light that it will float upon water. ***Obsidian*** is a kind of volcanic glass like red or green bottle glass. **Mud, water,** steam, vapors, and a variety of gases, sulphur, and **many kinds of** minerals, are among volcanic products.



Section showing the Structure of a Volcano.

The diagram represents a section of a volcano. The lower layers are the strata which are not of volcanic origin. Through these passes the shaft, or chimney, which at the summit is called "the crater." Immediately around this chimney are layers of scoriæ, or ashes, while on either side, and overflowing the original strata, are beds of lava. The cone is thus formed by a series of concentric layers of material which has been ejected from the crater.

42. **Active Volcanoes** are those now in eruption or which have been in eruption in recent years. **Extinct Volcanoes** are those in which the fires have gone out. Volcanoes are called **Dormant** when the internal fires remain quiet, but where faint indications of fire or heat are seen.

Although the terms "internal fires" and "burning mountains" are frequently used, it must not be understood that actual combustion is in progress in subterranean furnaces, the flames and smoke of which issue through the volcanic chimney. Volcanoes never emit flames, and the clouds of smoke sometimes described are, in reality, the condensing vapors of steam, which is undoubtedly the source of energy in some, if not all, volcanic eruptions.

From the proximity of the majority of the volcanoes to the sea-coast, it has been suggested that sea-water is probably in some way connected with volcanic force, and that the mountain-ranges which skirt the oceans are the results of gigantic volcanic upheavals. The existence of volcanoes along coast-ranges is, however, one of the results, rather than the cause, of the upheaval of mountain-

chains. Eruptions and lava-overflows occur along the lines of upheaval, because the fissures created in the crust by the folding and breaking of the strata afford easy avenues of egress. It is also uncertain whether sea-water plays any other than an indirect part in producing volcanic activity. The strata deposited on the sea-bottom naturally retain a large percentage of water. In time, as they are more deeply covered and exposed to the heat of the interior, the imprisoned water may be, and most probably is, converted into steam, and under the enormous pressure to which it is subjected it may reach a temperature sufficient to liquefy the surrounding rocks. The effort of the steam which is generated in some such way to escape from its subterranean prison eventually produces a volcanic explosion.

Palisades of the Hudson.

Volcanic action was more energetic in former ages than it is at present, and consequently the extinct volcanoes are very much more numerous than those which are now active.

The distinction between active, dormant, and extinct volcanoes cannot be sharply drawn. No volcano is equally active at all times, and many active volcanoes have remained so long dormant at some period that they were thought to be extinct.

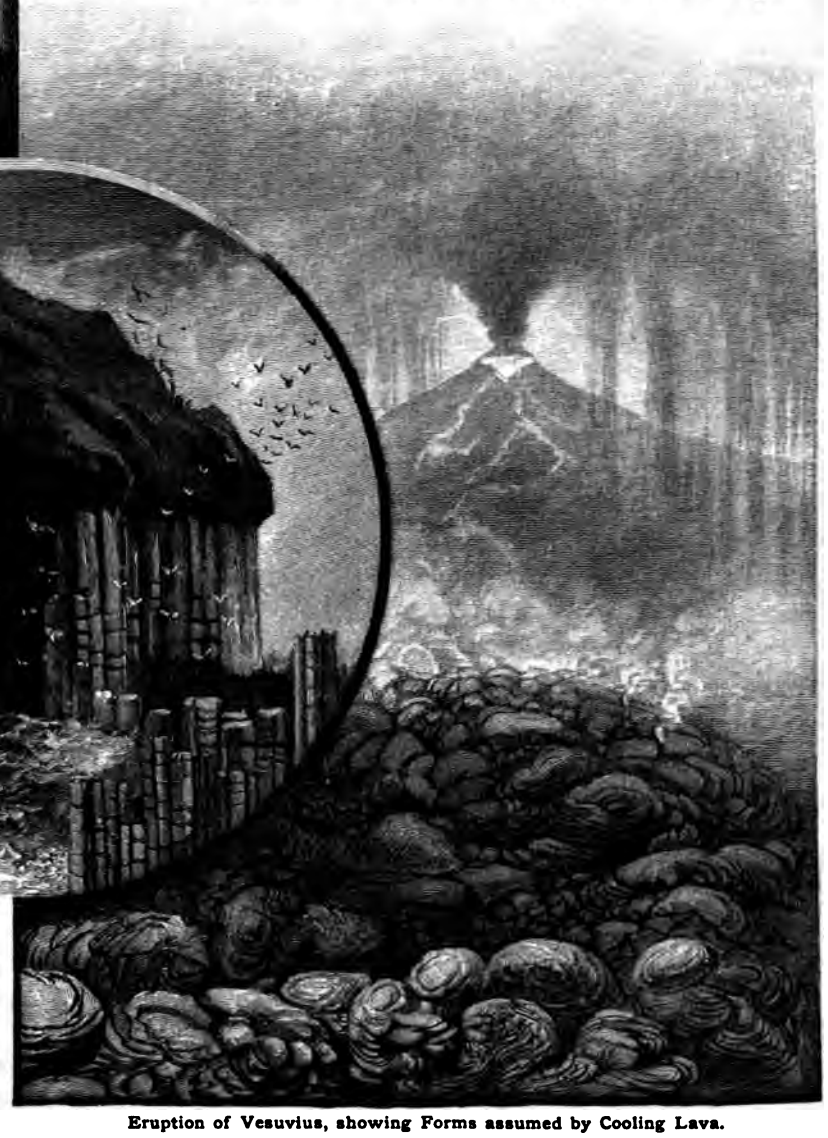
Vesuvius was believed by the ancients to be extinct. It had shown no signs of activity from the earliest antiquity, and the old crater was a hard saucer-shaped valley in which Spartacus encamped. In the year A. D. 79 it suddenly broke out into a state of eruption and destroyed the rich and prosperous cities of Herculaneum and Pompeii, situated near its base, and it has been active at intervals ever since.

Ometepee, in Lake Nicaragua, was, a few years ago, similar in its general appearance to many other apparently extinct volcanoes in Central America. It was a beautiful cone of regular shape, with no signs of fire and covered to its top with forests, while ranches lay about its base. In 1883 occurred an eruption which completely devastated the island.

The volcanoes of California, Oregon, and Washington are all supposed to be extinct; but it is known that a cinder cone in Northeastern California has been in eruption within forty or fifty years.

Gunong Galung-gung, one of the great volcanoes of Java, had been quiet from time immemorial. The site of the present crater was a broad, fertile valley, the inhabitants of which never dreamed of danger until one day in October, 1822, when began one of the most destructive eruptions of recent times. Besides the examples mentioned, many instances might be given of volcanoes which were believed to be extinct, but which were merely dormant.

43. **Lava** is the most abundant, as well as the most common, of volcanic products. This melted rock is not so fluid as water. It is viscous, and flows very much as a stream of tar or thick molasses might flow; and, as the progress of the stream is further retarded by the fact that the rapidly-cooling surface forms a solid rock, the actual progress of a lava-stream is usually rather slow. The flow of lava below the solid crust sometimes leaves long tunnels. Water would rush with great rapidity down a slope having an inclination of five or six degrees, but a lava-stream on such a slope creeps along but a few rods per hour. Its speed depends upon the size of the stream, the fluidity of the mass, and the steepness of the slope.



Fingal's Cave.

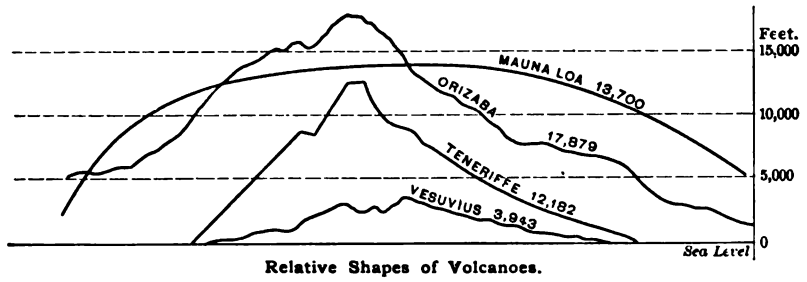
Eruption of Vesuvius, showing Forms assumed by Cooling Lava.

The viscous surface is often drawn into great wrinkles, and is sometimes roughened by being blown into large bubbles. As it cools it sometimes hardens into hard "basaltic" rock; at other times it becomes porous and spongy. The end of the lava-stream is usually more rough than the other portions, and is made up of fragments formed on the surface and broken again by the advancing current, by which they are frequently reunited. The lava in different parts of the stream cools into rocks of different characters.

The granite, basalt, and trap rocks owe their structure largely to the action of the internal heat of the earth. Rocks of this class, and all forms of lava, belong to the igneous rocks. Three well-known types are presented in the illustration.

44. **The Shape of the Volcano** and the steepness of the slope depend upon the prevailing character of the eruptions. If the discharge consists chiefly of lava, the slopes are usually gentle and the mountain is rather flat; if of solid materials, the peak is conical and steep.

The great volcano of Mauna Loa, in Hawaii, nearly 14,000 feet in height, which is made up entirely of lava, is a great broad dome in shape, and so flat at the top that the ocean is not in sight on either side. It stands in mid-ocean, and the whole height above the bottom of the sea is about 28,000 feet. The flatness of the mountain may well be illustrated by a model which, if made on the same scale horizontally and vertically, would, if six feet across, be but two inches high; and of this height one inch would represent the part which is above the level of the ocean.



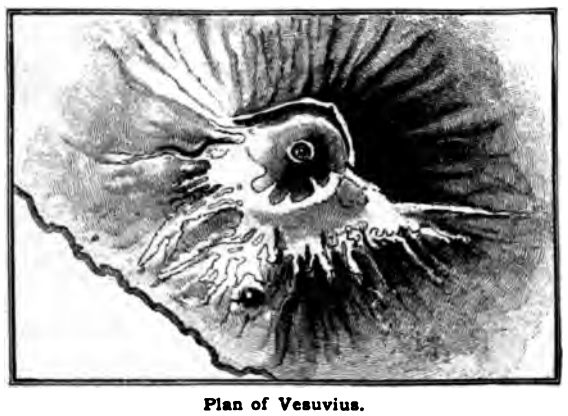
Relative Shapes of Volcanoes.

On the other hand, the great volcanoes along the western coast of America—and, indeed, most of the volcanoes of the world—are conical. Cotopaxi, Orizaba, Shasta, Etna, Vesuvius, Fujiyama, Ararat, are all examples of this class. Some of the volcanoes of this type are among the grandest and most picturesque peaks of the globe.

45. The **Crater** is a depression at or near the top of the mountain. Its shape and its appearance, like those of the mountain itself, depend upon the character of the eruptions. In the case of a conical mountain, it is usually a bowl- or funnel-shaped depression at the summit, with sloping sides surmounted by a ringlike ridge called the rim of the crater, which is rarely as much as half a mile across.

In dome-shaped volcanoes of lava it may be much larger, and is a pit with steeper and more rocky sides.

In the diagram is given a map or plan of Vesuvius, showing the comparatively small crater of modern times and the northern half of Monte Somma, which is the large partially-effaced crater-wall of the ancient volcano. Down the sides of the mountain are indicated the courses of the lava-streams.



Plan of Vesuvius.

The crater of Kilauea, in Hawaii, is the most noted example of an active volcano of the dome-shaped type. The top of the mountain is so flat that it seems like a great lava-plain, in which lies the enormous pit-like crater, very irregular in shape and some three miles long by a mile or more in width. The floor of this pit is from 400 to 1000 feet below the rim. The sides are precipices of lava. On the rough bottom is a pool of molten lava always in sight, at times reduced in size to an acre or two, and again—especially before great eruptions—rising and spreading out like a fiery lake.

This is the largest active crater in the world, but there are larger extinct craters. One on the island of St. Helena is described as a broken ring of basaltic cliffs eight miles by four in extent, while the old extinct crater of Asosan, in Japan, is said to be fifteen miles in breadth, with a population of 20,000 people living within its limits.

46. **Eruptions** are of many kinds. Volcanoes differ from one another in the character of their eruptions, and the same volcano does not always behave in the same manner at different times. Eruptions may, however, be rudely classed as the quiet and the explosive.

The Craters of Mauna Loa and Kilauea.

The more quiet eruptions are, as a rule, those of which the discharged matters consist chiefly of lava, although these are often preceded by earthquakes and minor explosions, which cease or become more subdued when the lava begins to flow. In such eruptions the lava does not usually flow over the edge of the crater, but more commonly bursts out through some crack in the sides of the mountain. Such has been the character of some of the more notable of the modern eruptions on the Hawaiian Islands.

An eruption occurred in Iceland in 1783 during which the lava flowed in opposite directions in two great streams, one forty and the other fifty miles long, filling a river-valley and spreading out, in places, into fiery lakes fifteen miles wide. The quantity of ashes was so great that much land was destroyed, and the finer dust in the upper air spread over Northern Europe to such an extent as to dim the sun. The eruptions of Vesuvius usually consist partly of lava and partly of ashes, cinders, etc.

In explosive eruptions great quantities of gas and steam are belched forth along with dust and fragments of rock. Sometimes the quantity of dust is so great as to darken the sky, and in falling on the surrounding country it often proves more destructive to life and property than any eruption of lava.

The eruptions of the grand volcanoes of Western America are chiefly explosive, and their conical shapes and steep slopes are due to the relatively large quantities of cinders and other solid material cast out.

Some volcanoes are in eruption almost incessantly; others, only after long intervals. The eruptions of the latter are apt to be the more violent. Rocks of eight or ten feet in diameter were thrown seven miles from the crater of Cotopaxi in an eruption which occurred in 1532, and Asamayama, in Japan, in an eruption in 1783, threw out rocks forty or fifty feet in diameter. In each case towns and plantations in the vicinity were destroyed. Sometimes, where much steam is ejected, heavy showers accompanied by vivid lightning result from the condensation of the vapors, and the rain, mingling with the dust, produces destructive torrents of mud on the sides of the mountain.

New volcanoes sometimes break out in old volcanic districts. In 1770 the new volcano of Izalco broke out near the old volcano of Santa Anna, in Salvador, and it has been in almost continuous eruption ever since, and is perhaps the most active of explosive volcanoes. Explosive eruptions of hot stones occur at intervals of from five to twenty minutes. The cone is now 3000 feet high, and the showers of glowing fragments about its summit have given it the name of "The Lighthouse of Salvador."

The volcano of Jorullo, in Mexico, came into existence in the midst of a fertile plain in 1759. It is in line with four other great volcanoes.

From the nature and variety of the phenomena and the scale on which they take place, volcanic eruptions are the most sublime of all spectacles. They have sometimes been dreadfully destructive to human life, and it is not to be wondered at that they play such a part in the mythology of different countries.

As illustrative of the destructive character of volcanic eruptions, one may be mentioned which occurred in 1815 on the island of Sumbawa, near the coast of Java, and which lasted a month. The sounds of the explosions were heard in Sumatra, 970 geographical miles distant, and in Ternate, 720 miles distant, in an opposite direction. The aggregate loss of life will never be known, but in the single province of Tomboro, of a population of twelve thousand, only twenty-six persons survived.

Eruptions of lava are sometimes from fissures or cracks in mountains or along mountain-chains. In previous geological times these were more frequent than now, and often on a grand scale. Eruptions of this character in the Sierra Nevada produced the famous Table Mountains of California. From such openings lava ran in great sheets, covering many thousand square miles in the Western United States.

47. **Submarine Eruptions** are those which take place beneath the sea. Many of the islands of mid-ocean are volcanic, and new islands have been thus made in recent times. Shoals have been formed, and the shape of the ocean's bed has been changed.

New islands were formed in the Grecian Archipelago in 1807, and in the Azores in 1720. The Island of Nyöe, near Iceland, was formed in 1783, but in a few years the storms and the ocean-waves beat it down, and only a rocky reef entirely under water now remains. In 1831 a new island appeared in the Mediterranean between Sicily and the Point of Tunis, where the ancient city of Carthage once stood. In July of that year an eruption took place where the water had previously been over 600 feet deep. Great columns of steam, water, and cinders shot upward, and large quantities of pumice floated about on the surface of the sea. A week later a small island was seen, which grew rapidly, and by August was 200 feet in height. An English captain then landed and took possession for his country, hoisting the British flag. The new island—which was named Graham Island—when the eruption ceased was composed of loose material, and was rapidly beaten down by the sea. It disappeared in the following winter, and a year later there were 150 feet of water over the spot which it had temporarily occupied.

48. Almost all the active volcanoes are near the sea, and many of them are on islands. With the exception of a few in the interior of Asia of which we have but little knowledge, they are all situated within less than 150 miles of the sea, and the vast majority of them very much nearer.

They are distributed in groups and lines. It is probable that the lines are along great cracks which extend through the more solid crust of the earth, and which coincide usually with the direction of chains of mountains.

These lines and groups are ranged in great belts. One of these belts nearly surrounds the Pacific Ocean, and includes all of the greatest volcanoes of the earth. Beginning in this chain or belt at Cape Horn, there is a group now active in the Andes of Chili; another in Ecuador, where the highest volcanoes of the globe are situated. Continuing north, there are groups in Central America and in Mexico, and a group of extinct volcanoes in the Western United States. To the northwest there are groups in Alaska and in the Aleutian Islands in which some of the volcanoes are active. Other groups are found in Kamchatka, the Kurile Islands, Japan, the Philippine and Sunda Islands to New Zealand.

Another belt not so well defined extends irregularly across Southern Europe to the Azores, and possibly around the world. There are also various scattered groups, like those of Iceland and the Hawaiian Islands.

The general map on pages 22 and 23 shows the relative position of these lines, and the special maps represent, on an enlarged scale, each of the more important groups with its prominent peaks.

There have been many attempts to explain by special theories the distribution of the volcanoes of the globe, but on this, as on the immediate causes of eruptions, scientists are not agreed.

Among the extinct volcanoes of the globe, those of the Western United States are perhaps the most remarkable. All the higher peaks of the Northern Sierra Nevada and of the Cascade Mountains are extinct volcanoes. Several of these are over 14,000 feet high, and there are hundreds of craters and peaks of lesser height. There were also countless fissure-eruptions, and lava and other volcanic products now cover an area of more than 200,000 square miles. The topography and aspect of a still larger region are dependent upon or modified by the volcanic character of this section.

These volcanoes appear to have broken out in the Tertiary and continued active until the present age. The volcanic material flowed over the stratified rocks, and, at some of the greatest peaks, is piled up more than 12,000 feet thick over the fossil-bearing strata. Most of the "table mountains" and the so-called "pedregals" of that region were made by old lava-flows.

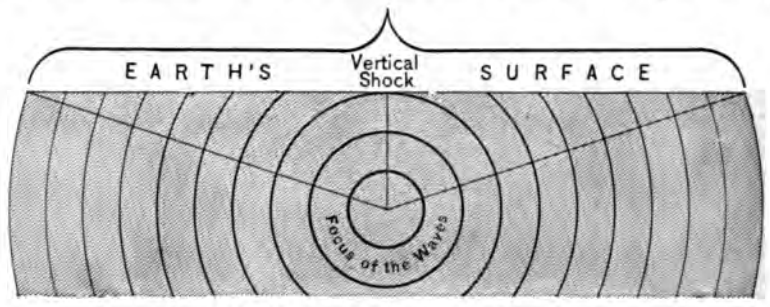
49. **Earthquakes,** as the name signifies, are quakings of the solid crust of the earth. They are most common in volcanic regions, and nearly always occur when an eruption takes place. They also often occur where there are no active volcanoes, and sometimes in localities far distant from them.

The quaking of the earth is spasmodic or intermittent, with intervals of quiet between the short separate periods of shaking, which are called **Shocks.**

The actual trembling of the ground varies in its peculiar characteristics. It may be either a sudden tremor or quiver, a rocking or wave-like motion, a shake, an explosive shock, or a combination of some or all of these. A whirling or twisting motion is often spoken of, but it is doubtful if this ever occurs.

The intensity of the shocks may vary from a mere jar, so slight as to be scarcely perceptible, to a heavier jar or gentle tremor, and so on to the most violent shocks, which destroy cities, shake down rocks from the mountains, break and displace the underlying strata, and change the level of the land.

50. The shocks are progressive—that is, they start from some spot or line and travel outward from it. There is always a central region in which the shock is most severe, and from which it moves in all directions, becoming less severe as it travels, until at last it ceases to be felt. It travels through the rocks of the crust as does a wave or an impulse, but, owing to the different character of different rocks and soils, the effects on the surface are not always uniform.



The Motion of Earthquake Waves.

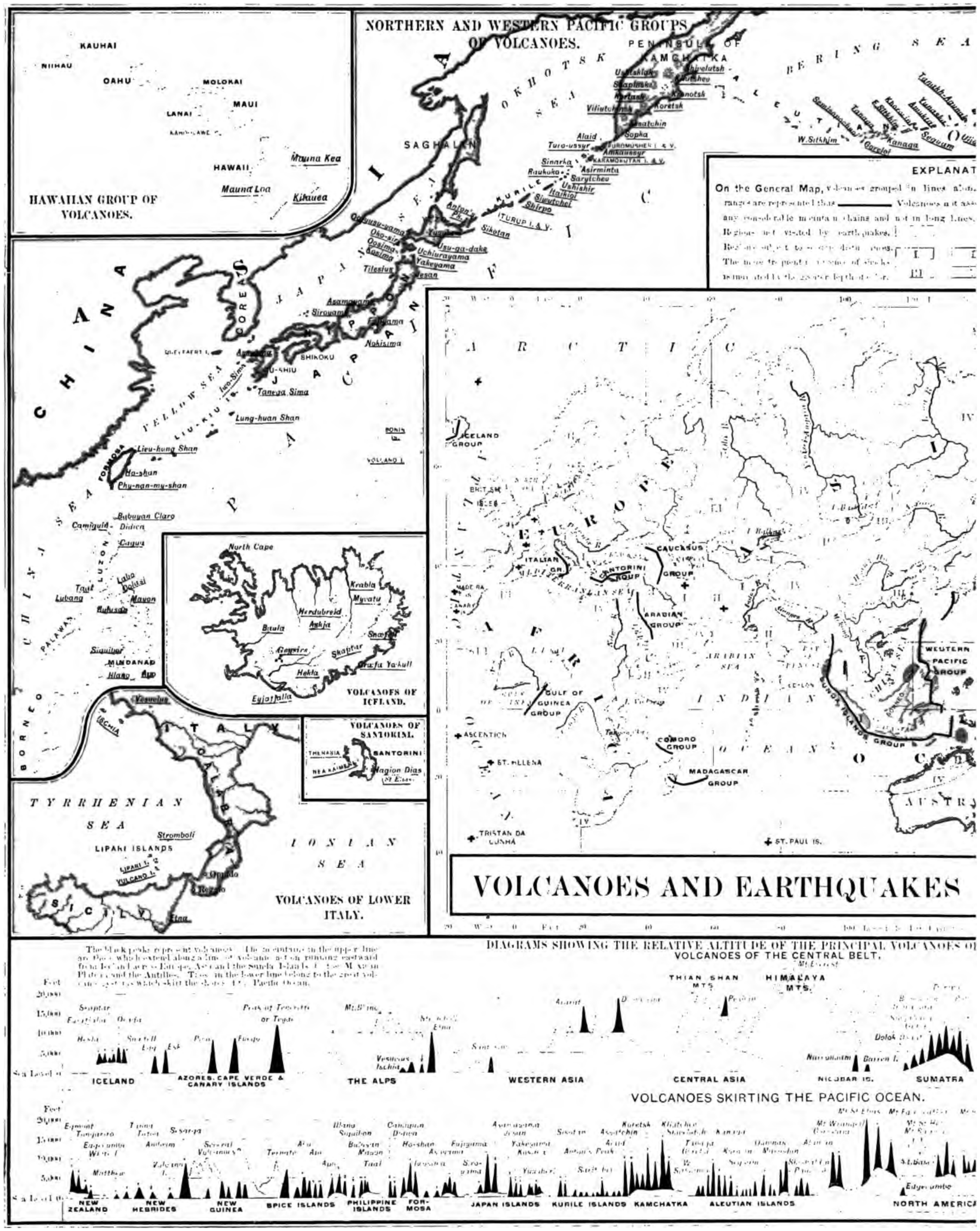
From the focus, at a point below the surface, the waves travel in all directions, as represented in the diagram. As the distance from the focus increases, the force of the waves is reduced, as is indicated by the diminishing thickness of the curved lines.

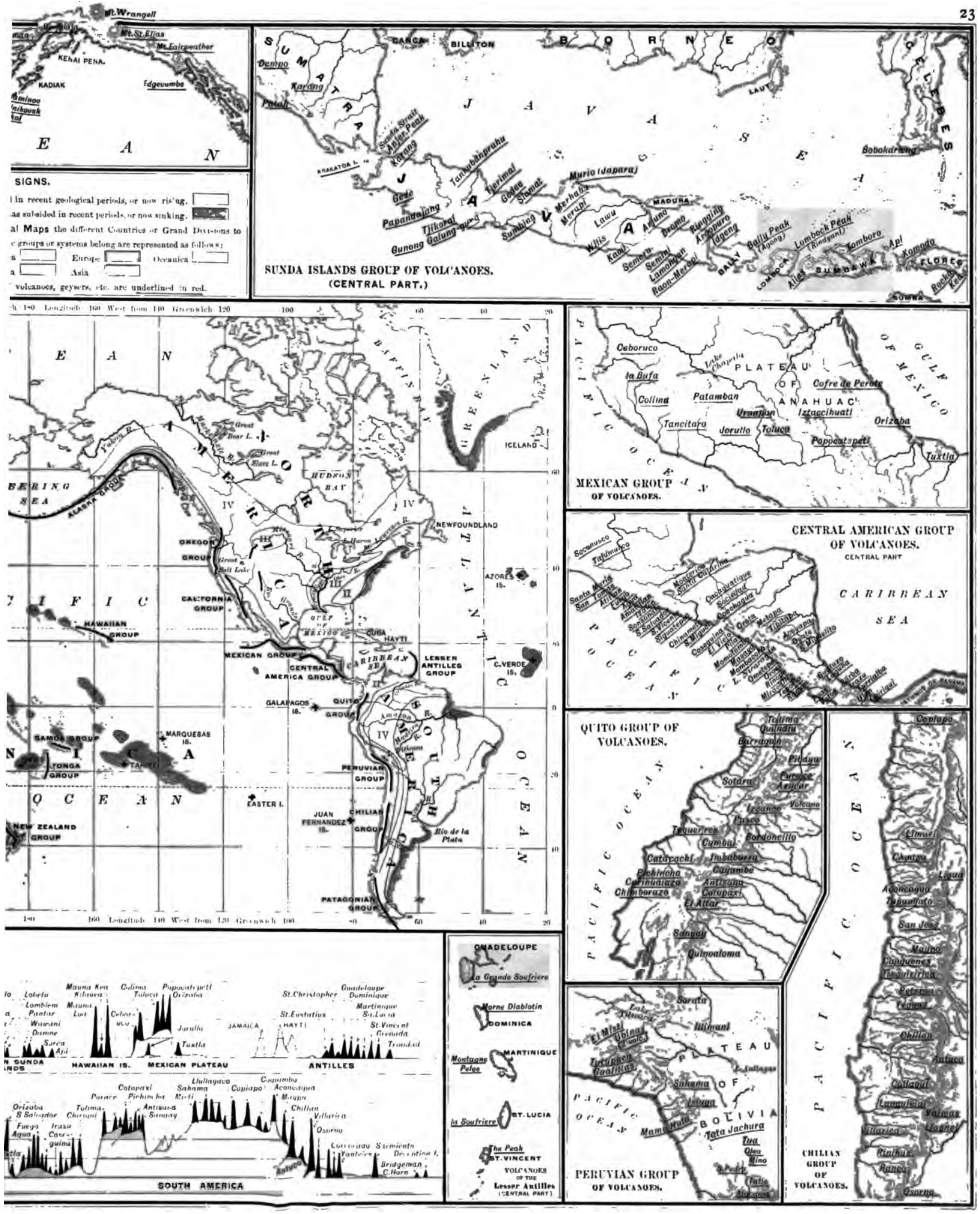
51. The velocity of the shock or wave is usually between 20 and 35 miles per minute, but it has been observed to be much less or much more than that. In India, observations have shown the velocity to be as low as 8 miles per minute, while that of the Charleston earthquake of 1886 was probably in certain directions 100 miles. The velocity is usually greater in some directions from the starting-point than in others.

52. The duration of a single shock is usually but a few seconds, and rarely so much as a minute. There may be long intervals between the separate shocks, or they may follow one another so quickly that several in succession may be mistaken for a single prolonged shock.

In countries especially subject to earthquakes there may be periods of repose lasting for months or years, or even for centuries, without any severe shocks, and then there may be a relatively short period during which the shocks are very much more frequent and heavier. The most destructive earthquakes have been of this class, particularly those of Southern Europe.

Near volcanoes they are much more frequent in occurrence, as well as more local in character. It has been said that at Caldera, in Chili, the earth trembles perpetually; this is probably an exaggeration. In Salvador three hundred and seventy-two shocks were recorded in six days in December, 1879. Of this large number, less than one-fifth continued longer than 10 seconds, and only two or three over 30 seconds. The longest lasted but 50 seconds.


VOLCANOES AND EARTHQUAKES
HAWAIIAN GROUP OF VOLCANOES.
KAUHAI
NIIHAU
OAHU
MOLOKAI
MAUI
LANAI
HAWAII
Mauna Kea
Mauna Loa
Kilauea
NORTHERN AND WESTERN PACIFIC GROUPS OF VOLCANOES.
PENINSULA OF KAMCHATKA
OKHOTSK SEA
BERING SEA
SAGHALIN
CHINA
COREA
YELLOW SEA
LIU-KIU IS.
FORMOSA
JAPAN
NIPPON
SHIKOKU
KURILE
ITURUP I. & V.
Sikotan
Anton's Pk.
Usu-ga-dake
Uchiurayama
Yakeyama
Tilesius
Asamayama
Siroyama
Fujiyama
Nohisima
Taneqa Sima
Lung-huan Shan
Lieu-hung Shan
Ho-shan
Phy-nan-my-shan
Babuyan Claro
Camiguin
Didica
Cagua
LUZON
Taal
Lubang
Mayon
Bulusan
PALAWAN
Siquibor
MINDANAO
Apo
BORNEO
CHINA SEA
Alaid
Turo-ussyr
Sinarka
Raukoko
Asirminta
Sarytcheu
Ushishir
Itaikioi
Siwutchei
Shirpo
Sopka
Koretsk
Viliutchinsk
Kronotsk
Shivelutsh
Kliutshev
W.Sitkhim
Semisopochnoi
Tanaga
Gorelot
Kanaga
Seguam
Amukta
Yunaska
Tanakh-Agunah
VOLCANOES OF ICELAND.
North Cape
Krabla
Myvatu
Herdubreid
Askja
Baula
Geysirs
Skaptar
Snæfell
Orafa Yökull
Hekla
Eyjafjalla
VOLCANOES OF SANTORINI.
THERASIA
NEA KAIMENI
SANTORINI
Hagion Dias
VOLCANOES OF LOWER ITALY.
ITALY
CALABRIA
Vesuvius
ISCHIA
TYRRHENIAN SEA
IONIAN SEA
Stromboli
LIPARI ISLANDS
LIPARI I.
VULCANO I.
SICILY
Etna
EXPLANATION
On the General Map, Volcanoes grouped in lines along ranges are represented thus. Volcanoes not associated with any considerable mountain chains and not in long lines. Regions not visited by earthquakes. Regions subject to severe disturbances. The more frequent occurrence of shocks is indicated by the greater depth of shading.
ARCTIC
EUROPE
ICELAND GROUP
BRIT. ISLES
ITALIAN GR.
MEDITERRANEAN SEA
SANTORINI GROUP
CAUCASUS GROUP
ARABIAN GROUP
ARABIAN SEA
AFRICA
GULF OF GUINEA GROUP
ASCENTION
ST. HELENA
TRISTAN DA CUNHA
COMORO GROUP
MADAGASCAR GROUP
INDIAN OCEAN
ST. PAUL IS.
SUNDA ISLANDS GROUP
WESTERN PACIFIC GROUP
AUSTRALIA
DIAGRAMS SHOWING THE RELATIVE ALTITUDE OF THE PRINCIPAL VOLCANOES OF
VOLCANOES OF THE CENTRAL BELT.
Feet
20,000
15,000
10,000
5,000
Sea Level 0
ICELAND
AZORES, CAPE VERDE & CANARY ISLANDS
Peak of Teneriffe or Teyde
THE ALPS
Vesuvius
Ischia
Etna
Ararat
WESTERN ASIA
THIAN SHAN MTS.
CENTRAL ASIA
HIMALAYA MTS.
NICOBAR IS.
Barren I.
Dolok
SUMATRA
VOLCANOES SKIRTING THE PACIFIC OCEAN.
NEW ZEALAND
NEW HEBRIDES
NEW GUINEA
SPICE ISLANDS
PHILIPPINE ISLANDS
FORMOSA
JAPAN ISLANDS
KURILE ISLANDS
KAMCHATKA
ALEUTIAN ISLANDS
NORTH AMERICA
Mt. St. Elias
Mt. Wrangell
Edgecumbe


SUNDA ISLANDS GROUP OF VOLCANOES.
(CENTRAL PART.)
B O R N E O
J A V A S E A
SUMATRA
BILLITON
CELEBES
Dempo
Karang
Krakatoa I.
Gede
Papandajang
Tjikorai
Gunong Galung-gung
Merapi
Lawu
Madura
Bromo
Bally
Lombock
Sumbawa
Flores
Sumba
Bobokarang
SIGNS.
Mt. Wrangell
Mt. St. Elias
Mt. Fairweather
Kenai Pena.
Kadiak
Edgecumbe
BERING SEA
ALASKA GROUP
OREGON GROUP
CALIFORNIA GROUP
HAWAIIAN GROUP
MEXICAN GROUP
CENTRAL AMERICA GROUP
LESSER ANTILLES GROUP
GALAPAGOS IS.
QUITO GROUP
PERUVIAN GROUP
CHILIAN GROUP
PATAGONIAN GROUP
JUAN FERNANDEZ IS.
EASTER I.
MARQUESAS IS.
SAMOA GROUP
TONGA GROUP
TAHITI
NEW ZEALAND GROUP
AZORES IS.
C. VERDE IS.
NEWFOUNDLAND
ICELAND
GREENLAND
BAFFINS BAY
HUDSONS BAY
GULF OF MEXICO
CARIBBEAN SEA
CUBA
HAYTI
Rio de la Plata
NORTH AMERICA
SOUTH AMERICA
ATLANTIC OCEAN
PACIFIC OCEAN
MEXICAN GROUP OF VOLCANOES.
PLATEAU OF ANAHUAC
GULF OF MEXICO
Ceboruco
La Bufa
Colima
Tancitaro
Patamban
Jorullo
Toluca
Iztaccihuatl
Cofre de Perote
Orizaba
Popocatepetl
Tuxtla
CENTRAL AMERICAN GROUP OF VOLCANOES.
CENTRAL PART
CARIBBEAN SEA
PACIFIC OCEAN
Soconusco
Tajumulco
QUITO GROUP OF VOLCANOES.
PACIFIC OCEAN
Tolima
Huila
Purace
Sotara
Pasto
Cumbal
Cotacachi
Imbabura
Cayambe
Pichincha
Antisana
Cotopaxi
Chimborazo
El Altar
Sangay
GUADELOUPE
La Grande Soufriere
Morne Diablotin
DOMINICA
Montagne Pelee
MARTINIQUE
la Soufriere
ST. LUCIA
The Peak
ST. VINCENT
VOLCANOES OF THE Lesser Antilles (CENTRAL PART)
PERUVIAN GROUP OF VOLCANOES.
PLATEAU OF BOLIVIA
PACIFIC OCEAN
Sorata
Illimani
El Misti
Ubinas
Sahama
Tata Jachura
CHILIAN GROUP OF VOLCANOES.
PACIFIC OCEAN
Copiapo
Aconcagua
Tupungato
San Jose
Maipu
Chillan
Antuco
Villarica
Osorno
SUNDA ISLANDS
HAWAIIAN IS.
MEXICAN PLATEAU
ANTILLES
SOUTH AMERICA
Mauna Kea
Kilauea
Popocatepetl
Orizaba
Jorullo
Tuxtla
JAMAICA
HAYTI
St. Christopher
Guadeloupe
Dominique
Martinique
St. Lucia
St. Vincent
Grenada
Trinidad
Cotopaxi
Sahama
Llullayaco
Coquimbo
Aconcagua
Copiapo
Chillan
Villarica
Osorno
Corcovado
Sarmiento
C. Horn

53. Among the many phenomena which occur in connection with earthquakes are underground noises, the formation of cracks in the earth, the ejection of water and sand from cracks and holes, changes in level made by portions of the surface rising or sinking, land-slides, and the moving or twisting of loose rocks from their places. Sometimes the two sides of a crack or fault rise or sink unequally, so that one side is left higher than the other. Sometimes magnetic disturbances and numerous other phenomena have been observed.

54. Earthquakes are most frequent and violent in the regions of active volcanoes, and after these in the volcanic belts described in paragraph 48. It is probable that no part of the earth is entirely exempt from earthquakes, but over much of the globe they occur only as mere tremors. Some severe earthquakes have, however, taken place at a considerable distance from active volcanic centers; as, for example, that of New Madrid, Mo., 1812, and of Charleston, S. C., 1886.

Earthquakes are most liable to occur along great faults (see paragraph 38) and at the junction of unlike geological formations.

55. Some earthquakes are extremely local in character; others disturb an enormous area, and the extent of territory shaken does not depend entirely upon the violence of the shock.

Of the three hundred and seventy-two shocks observed in Salvador in December, 1879, many were not felt more than 10 miles away from the center of disturbance, and some of considerable severity extended only a few miles farther. On the other hand, some of the earthquakes of the Eastern United States which have been too slight to do any damage have been felt over a territory of 200,000 or more square miles.

The great Lisbon earthquake of 1755, which destroyed over one hundred thousand lives, disturbed an area of 12,000,000 or 14,000,000 square miles. It extended entirely across the Atlantic Ocean, and was felt in New England.

56. Enormous sea-waves often start with an earthquake and cause great destruction on the neighboring coasts. They roll with immense velocity to great distances, and at places where they might not otherwise be noticed they are recorded on the tide-gauges.

During the Lisbon earthquake, in 1755, a wave 40 feet high swept up the Tagus; the same wave at Cadiz was 60 feet in height. In the earthquake which destroyed Lima and Callao in 1746 a great wave swept the coast and destroyed twenty-three vessels, carrying one frigate several miles inland. An earthquake in Japan in 1854 produced waves that were recorded on the tide-gauges at San Francisco; they were carefully studied, and will be referred to again. (See p. 56.) Many similar waves have been noticed since.

57. Numerous theories have been proposed to explain the causes and phenomena of earthquakes, yet none have been entirely accepted. Scientists are agreed as to the general causes, but the details are explained by various hypotheses. It is probable, however, that mountain-chains were elevated, the strata bent, crumpled, and broken, and the faults made, in connection with earthquakes, and that mountain-building has not ceased on the earth.

The destruction of Krakatoa in July and August, 1883, was perhaps the most remarkable eruption of modern times. As it has been studied more completely than any other and with the aid of scientific instruments, it may be especially described as illustrating the various phenomena of earthquakes and eruptions.

Up to 1883, Krakatoa was known as an uninhabited rocky island 6 or 7 miles long by 3 or 4 wide and 2400 feet high, situated in the Strait of Sunda. It was of volcanic origin, but was considered to be an extinct volcano, and it was clothed with luxuriant tropical forests to its very summit.

The disturbance began with earthquakes and explosive eruptions in July, and culminated in the destruction of the island in August. The earthquakes shook the neighboring lands and raised great sea-waves, which swept and desolated the populous coasts of the adjacent islands. A steamer was carried from one of the harbors and left 3 miles inland. A sea-wave rolled across the Indian Ocean in one direction and across the Pacific in the other, and was recorded on the tide-gauges from New Zealand to Japan and California.

The explosions were heard at points distant hundreds of miles in different directions, and it is estimated that more than 12 cubic miles of gas, steam, cinders, pumice, ashes, and other materials, were belched forth. A grand explosion in August blew the island into pieces and scattered the fragments far and wide. Only a small part of the original island now remains, the larger fragments forming new and smaller islands, but most of the material was scattered over the sea. The aspect of the land was entirely changed, and the bottom of the sea so altered that new surveys and new soundings have been made for the use of navigators.

The pumice thrown out floated away on the water in great fields of loose pieces several feet thick, which extended as far as the eye could reach, and through which ships plowed their way for days together; and one great mass was seen in the Indian Ocean, 700 miles distant, more than one year later.

The finer dust was carried into the upper air by the explosion, and wafted by the winds in such quantities and to such great distances that it is believed to have been the cause of the wonderful and brilliant sun-glows which were observed later in the year in Europe, over most of America, and in many of the islands of the Pacific Ocean, and westward to China and Japan.

This great explosion produced a wave of atmospheric pressure which went entirely around the globe, and was recorded on all the self-registering barometers of the observatories of the world.

The ashes falling on the neighboring countries destroyed populous regions and caused dreadful suffering. In places, the ashes became mixed with water and covered everything with mud so deep as to produce complete desolation. The fertile and densely-populated islands of Sibuku and Sibesi, when visited later, were found covered with dried mud and ashes, and, "of their inhabitants, all perished to a man." The total loss of life can never be known, but it is estimated to have been over one hundred thousand.

58. **Hot Springs** are those in which the waters are heated by coming in contact with warm or hot rocks somewhere in their underground courses, and are therefore most abundant in volcanic and mountainous regions.

Hot springs are very often mineral springs, from the fact that hot water has much greater solvent power than cold water; and many hot springs have long been noted for their medicinal and curative properties. Several thousands have been described in Southern Europe, and more than twelve hundred are known in France and Spain. In the United States there are a few east of the Rocky Mountains, but west of them there are hundreds, if not thousands.

59. **Geysers** are hot springs from which boiling water and steam are thrown out in intermittent eruptions. The water spouts to the height of 200 feet in the greater geysers, at intervals varying from less than one hour to more than one day. The eruption is usually soon over, and the frequency depends upon the season.

The most celebrated geysers of the world are those of Iceland—which have long been known—those of the Yellowstone region, and those of New Zealand.

Geysers are caused by the water percolating into the deep cavities in the hot rocks which have openings to the surface. In the depths the water becomes heated under pressure. The eruption starts with comparative gentleness until the pressure becomes partly removed. The remaining water then boils very much more rapidly, and, with the steam produced, is thrown out with great violence until the cavity or cavities are emptied. The geyser is then quiet until the water again flows in and becomes heated.

Questions.—What is probably one of the causes of volcanoes and earthquakes? How are hot springs produced? What is a volcano? Name some of the volcanic products. What is an active volcano? An extinct volcano? Give an illustration of a volcano supposed to be extinct which afterward proved to be active. What is the principal agent in producing volcanic eruptions? What is lava? Describe the flow of a lava-stream. Upon what does the shape of a volcano depend? Give examples of dome-shaped and conical volcanoes. What is a crater? Which is the largest active crater in the world? Are volcanic eruptions always the same in character? Describe some of the eruptions mentioned in the text. What is said of submarine eruptions? Where are most of the active volcanoes situated? How are they distributed? What extinct volcanoes are especially remarkable? Where are earthquakes most frequent? What is the nature of the motion? What is said of the progress, velocity, and duration of shocks? What are some of the accompaniments of earthquakes? Describe the Krakatoa eruption. Where are hot springs most abundant? What is a geyser?

VIII. Magnetism.

60. A **Magnet** has the property of specially attracting iron. There is a mineral—a kind of iron-ore called *lodestone*—which naturally has this property, but most magnets are artificially made. Steel—which is not a magnet naturally—can be magnetized by contact with another magnet, by means of electricity, and in various other ways. When magnetized, it retains the magnetic properties for a long time, and hence is called a permanent magnet. Soft iron may be made magnetic in the same way as steel, but it does not retain its magnetism.

A slender bar of steel balanced and suspended so that it may turn freely is called a magnetic needle.

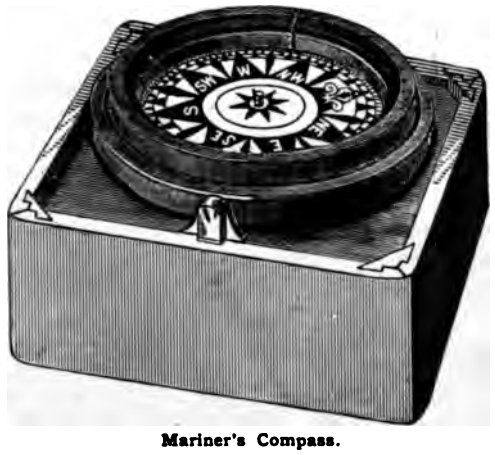
61. A magnetized bar of steel, or a magnetic needle, will attract iron-filings to itself when placed near them; but the filings will not be attracted to all parts alike: they are attracted principally near the ends. The points of greatest attraction are called the **Poles,** and are beneath the surface, near the ends of the magnet.

A Magnet Attracting Iron Filings.

If the iron filings be sifted upon the surface of a piece of paper or glass under which a bar-magnet has been previously placed, the particles of iron will arrange themselves in certain peculiar curves, which are quite distinctly marked and which are called lines of magnetic force.

62. When a magnetic needle is properly balanced and suspended so as to move easily, as on a pivot, it soon turns and assumes some particular direction, which is called the **Magnetic Meridian.** In some places this direction is exactly north and south, and over most of the earth where it is not exactly north and south it is nearly so. The end of the needle which points in a northerly direction is called the north pole of the magnet.

63. The common compass consists of a magnetic needle properly suspended on a pivot, so that it may move over a scale marked with points or divided into degrees, and the whole enclosed in a suitable case for protection and observation. The mariner's compass has the needle fastened to the under side of a card, which turns with it, and on which are marked the "points of the compass." The whole is suspended in such a way that it may remain horizontal whatever the motion of the ship.



Mariner's Compass.

Before the invention of the compass no voyages could be safely made far from the coast. Ships could sail a short distance, directing their course by the position of the heavenly bodies; but the mariner was obliged to rely almost entirely upon landmarks in guiding his vessel. The broad ocean was indeed pathless, and could not be crossed and a return-route found until this instrument was devised. It came into use in Europe in the twelfth or thirteenth century, but was not common until later.

In a very crude and imperfect form, the compass was known to and used by the Chinese, who employed it in traveling overland through the interior of Asia, long before it made its appearance in Europe. The improvements in the mechanism of the compass and an increased knowledge of the principles of magnetism awakened a desire for navigation which resulted in the discovery of the New World.

64. When two magnets are brought near together, they influence each other. Like poles repel, and unlike poles attract. For example, the north pole of one magnet will attract the south pole of another magnet. Magnetic needles are turned from the position they might take by masses of iron or steel or by other magnets brought near them, by currents of electricity, and in many other ways.

65. **The Earth itself is a Magnet,** and this probably accounts for the fact that the magnetic needle assumes some particular direction. Like other magnets, the earth has its poles; and if the magnetic poles were at or under the true geographical poles, then the magnetic needle would everywhere point truly north and south, and the magnetic and geographical meridians would coincide.

66. The magnetic poles of the earth are not at the true poles, and are not so sharply defined; therefore the magnetic needle does not point truly north and south over the greater part of the earth, and the magnetic meridians do not coincide with the geographical meridians, and, moreover, are not nearly so regular.

Magnetic Variation (often called **Magnetic Declination**) is the difference between the true north and the direction in which the needle points. In some parts of the earth the needle points east of the true north, and this is called easterly variation. When it points west of north, the difference is called westerly variation.

Lines drawn upon a map or a globe through places of equal variation are called **Isogonic Lines,** or, more simply, lines of equal variation. They are very irregular curves, and as a whole do not follow any known geographical features of the globe. (See Map.) The topographical features of a country affect them very slightly—too little to be considered in any but the most exact calculations.

67. If a steel bar or needle be carefully balanced so as to hang perfectly level, and then magnetized, it will no longer hang level (over most of the earth), but must be balanced anew if we wish to use it in a compass. Without this precaution one end will be depressed, and this depression is called **the Dip** (or **Inclination**) **of** the needle; therefore a needle properly suspended to show the amount of depression is called a **Dipping-Needle.**

Lines drawn through places of equal dip are called **Isoclinal Lines,** or, more simply, lines of equal dip. They pass around the earth in a general easterly-and-westerly direction, but they do not coincide with the parallels of latitude, nor with any other known geographical feature; nor are they regular mathematical curves. That part of the earth in which the needle remains level is called the **Magnetic Equator.** This lies north of the true equator over most of the Eastern Hemisphere, and south of it over most of the Western Hemisphere.

South of this line the north pole of the needle will rise above the level; north of the line it will be depressed more and more, until at the magnetic pole it will stand in a vertical position, the north pole pointing directly downward.

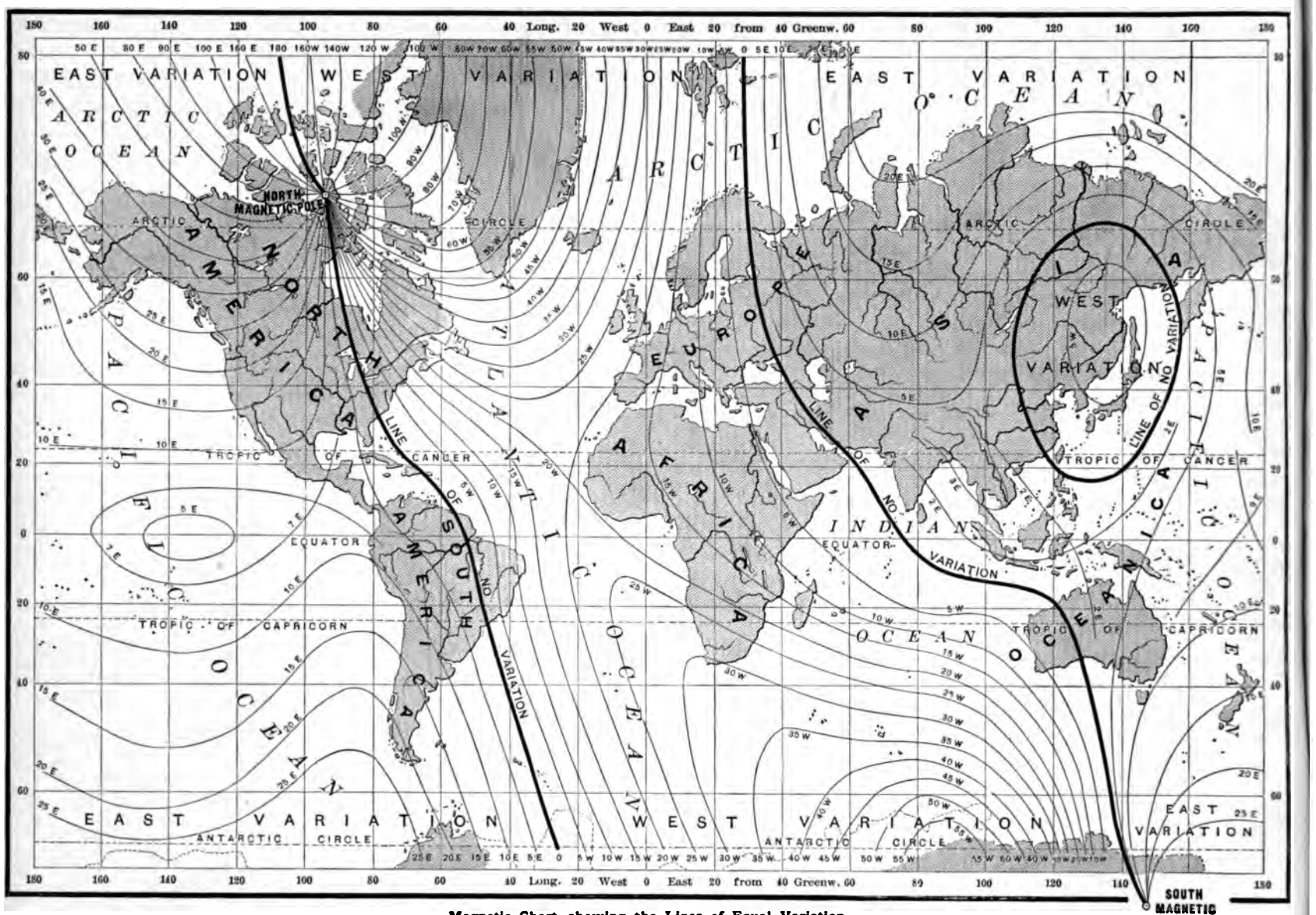
From the irregularity of the lines of equal variation and equal dip, it is obvious that there is no spot on or in the earth toward which the needle will always point from all parts of the surface. The term magnetic poles is, however, used for convenience.

68. The intensity of the magnetic force which directs the needle also varies, and the lines of equal intensity are also irregular curves which do not coincide with any other known geographical feature.

The safety of all ships at sea depends upon an accurate knowledge of the behavior of the compass. A ship that should attempt to sail from Boston to Liverpool by compass, and make no allowance for variation, would never reach any part of Europe, but would sail in a curve up into the Arctic Ocean.

Most of the lines which mark the boundaries of lands and of estates have been run by compass, during the last two or three centuries, in those countries settled by people of our civilization.

Owing to the vast importance of a correct knowledge of the behavior of the magnetic needle, great sums of money and much time have been devoted to the study of magnetism.



Magnetic Chart, showing the Lines of Equal Variation.

By consulting the map, it will be seen at once that the points designated as magnetic poles do not coincide with the geographical poles. It will also be observed that a line passes through the north magnetic pole, which south of that point is marked 0°, and north of it 180°. This means that anywhere along this line there is no declination of the needle, and that in the high latitudes of North America the north pole of the needle points to the south. To the east of this line in North and South America, the needle points west of north. The variation increases rapidly in the high latitudes of North America; but after reaching 25° to 30° it gradually diminishes in the Eastern Hemisphere until another line of no variation is reached, which passes through Europe, Eastern Asia, and Australia. The declination of the needle is then east of north, and gradually increases till a third line is reached, along which the needle does not vary. This line is nearly oval in shape, and includes Japan. Within its limits the declination is west. From this point the variation is again easterly till the first line of no variation is reached.

69. There is no place on the globe where the magnetic needle always points in the same direction. The magnetic poles of the earth slowly change position; consequently, the magnetic variation and the dip at any place also change from year to year, but this change is not regular. Several observers have made expeditions to the principal north magnetic pole, and since 1831, when first visited, it has traveled many miles to the westward.

Observations at Paris have been continued over three hundred years, and illustrate the changes in variation. In 1580 the point was 11½° east. It became less until 1663, when the needle pointed to the true north. Then the variation became west, and increased until 1814, when it amounted to 22½°. Then it turned backward, and has since been growing less, and is now about 22°.

There is a small daily, and also a yearly, fluctuation of the needle, the daily fluctuation increasing in amount as we approach the magnetic pole. In our latitude it is but part of one degree. The Arctic observations near Fort Rae show that the fluctuations there were on some days less than ½ of a degree, and on others over 11°.

There are also occasional sudden fluctuations—known as **Magnetic Storms**—when the movement, although slight, is violent and irregular as compared with the natural movements of the needle. These storms are usually accompanied with auroral displays, and with a disturbance of the electrical currents of the earth. Magnetic disturbances also sometimes accompany earthquakes.

70. The causes of the earth's magnetism are unknown, as are also the causes of the changes in variation. They all appear, however, to be in some way related to the sun's energy—partly to its regular heat, and partly to its irregular spots.

The formation of a great sun-spot was accompanied by a magnetic storm all over the world on November 17, 1882. The needles were affected at the same time at Cape Horn, Paris, throughout the United States, and elsewhere. There was a brilliant auroral display in both Europe and America; and in parts of the United States the telegraphic-lines were so affected that in some cases the batteries were disconnected and messages sent by the ground-current alone.

Questions.—What is a magnet? A permanent magnet? A magnetic needle? What are the poles of a magnet? Where are they situated? What is a magnetic meridian? What is a compass? Describe the mariner's compass. What effects have magnets upon one another? Why do magnetic needles assume some particular direction? Are the magnetic poles of the earth stationary? What is magnetic variation or declination? What is dip or inclination? What are isogonic lines? Isoclinal lines? Upon what does the safety of ships depend? Are the causes of the earth's magnetism known?

REVIEW AND MAP QUESTIONS.

What is Geography? What are its three main branches? Of what does Mathematical Geography treat? In what phase does Physical Geography consider the earth? How does it differ from Political Geography? What are the four important divisions of Physical Geography?

Of what is the universe composed? What are fixed stars? What is the solar system? What is known of the composition of the sun and the stars? Which is relatively heavier, the earth or the sun?

What is the shape of the earth? What imaginary lines are drawn on the earth's surface? What is longitude? What is latitude? What motions has the earth? What causes the succession of day and night? By what are the changes of the seasons caused? What is meant by perihelion? By aphelion? At what time of year does each occur? Which has the longer winters, the Northern Hemisphere or the Southern Hemisphere? Into what zones is the earth divided? What imaginary lines bound them? What is a map? What is map projection?

Of how many distinct elements are the various substances which constitute the earth composed? What is the theory of Laplace? How was the earth's crust formed? How are rocks classified? What are strata? How were they formed? How do they become exposed to view?

What are fossils? What do they teach? What has been the general character of the development of life on the globe?

What is Geology? What is meant by a geological era? Into what ages is the Archæan Era divided? What is the characteristic feature of the Azoic Age? Why was the Eozoic Age so named?

Into what ages is the Palæozoic Era divided? What forms of life appeared in the Silurian Age? What type of animal life became dominant in the Devonian Age? What was the remarkable feature of the Carboniferous Age? What was the probable character of the atmosphere and climate? How was coal formed? What is the difference between bituminous coal and anthracite coal?

In what era did the great development of reptiles occur? How did their form and size compare with those of reptiles now alive? What other type of animal life did the skeletons of some of these reptiles resemble?

What era is now in progress? What form of animal life is typical of the Tertiary Age? How did the climate of the Tertiary Age compare with that of the present age? How were the successive types of life adapted to the geological changes?

Did the geological changes of the remote past differ essentially from those now in progress? Is the action as violent now as in previous ages? What is erosion? What is its chief agent? Name some of the processes by which it accomplishes its work. What other agent produces changes of level? Has the earth's crust been fixed or changeable during the geological ages? How is this proved? How are mountains made?

Why are volcanoes, earthquakes, and hot springs treated together? How do volcanoes differ from other mountains? How do they differ from one another in shape? How do the eruptions differ? What form of lava eruptions was frequent in previous geological ages? In what section of the United States has the topography been greatly modified by volcanic action? What are earthquakes? Describe the peculiar characteristics of a shock. What effect does a severe earthquake often produce in the sea? What are hot springs? How do geysers differ from other hot springs? Where are the noted geyser-regions?

What are the properties of a magnet? Are the magnetic poles of the earth coincident with the geographical poles? What is magnetic declination? What precaution is necessary in balancing a needle for use in a compass? Of what value is the compass? Does the needle always point in the same direction? Where does the north pole of the needle point toward the south? Where are the lines of no variation? Is the intensity of the earth's magnetism uniform? What are magnetic storms?

(*For answers to the following questions consult the map of volcanoes and earthquakes, pages 22 and 23.*) How are volcanoes which are grouped in lines along mountain-chains represented on the map? How are the more isolated volcanoes represented?

Are volcanoes more numerous near the sea or in the interior of the continents? Where are the largest volcanoes of the earth situated?

On which coast of North America are volcanic groups found? On which coast of South America? Where are the principal volcanoes of Asia located? Of Europe? Which of the large continental masses have but few volcanoes?

Which is the most southern group of volcanoes in South America? What is the next group toward the north? What two groups between the latter and the Isthmus of Panama?

Which is the most southern group of North America? What group is immediately north of this? What groups are found in the Western United States? Are the volcanoes in these groups now active? What extensive group in the northwestern part of North America?

Which is the most northern group of Asia? What group south of this? What volcanic group is east of the China Sea? Name the important groups from west to east between the Bay of Bengal and Tahiti. What two groups in the Pacific Ocean between Asia and North America? What group southeast of Australia?

What groups are situated north of the Mediterranean Sea? What group between the Black and Caspian Seas? What group lies to the east of the Red Sea? What group off the western coast of Africa?

What volcanic island is situated in the North Atlantic Ocean? What group of volcanoes east of the Caribbean Sea?

Name some of the important volcanic islands, not belonging to lines or groups of volcanoes, in the Pacific Ocean. In the Atlantic Ocean.

What is the highest volcanic peak in South America? Name two lofty volcanoes in Mexico. What is the highest volcano of North America? Of Europe? Name two high volcanic peaks in Western Asia. What high volcanic peak in the Canary Islands?

In what country is Aconcagua? East of what lake are Sorata and Illimani? In what volcanic group are Chimborazo and Cotopaxi?

In what group are San Salvador, Ometepee, and Izalco? Where is Jorullo? Where is Mount Wrangell? Mount Fairweather? Mount St. Elias?

Which is the highest peak in the Kamchatka group? Where is Asamayama? Fujiyama? Ho-shan? Illano? Between what large islands is Krakatoa? Where is Gunong Galung-gung?

Where is Vesuvius? Etna? Stromboli? Where is Mount Hekla? Where is Mauna Loa? Kilauea? Mauna Kea?

Are the regions of the earth which are most subject to earthquakes in the vicinity of or remote from lines of volcanoes? What parts of North America are most frequently visited by earthquake-shocks? In what part of South America are seismic disturbances most common?

Are earthquakes more frequent in Northern Europe or in Southern Europe? In what sections of Asia do earthquakes generally occur? Name some of the large islands which are especially subject to earthquake-shocks.

Where is sinking land to be found in North America? Where is the land rising? What portions of South America are sinking? What areas are sinking in Asia? In Africa? Is the coast of Australia rising or sinking? What is the condition of the southern coast of Greenland? Are the Hawaiian Islands rising or sinking? The Madeira Islands? The Canary Islands? The Cape Verde Islands?

THE LAND.

I. Distribution and Shape of the Land.

1. As has already been stated, the crust of the earth is roughened and wrinkled, the higher parts constituting the land and the lower portions the great depressions which are occupied by the oceans.

A glance at the map of the world shows that the land constitutes a much smaller part of the visible surface of the earth than the water, and that it is distributed in irregular masses, separated from one another by the oceans, which are continuous.

Vast regions about the poles have not been explored, and many countries have been only incompletely surveyed; so that we do not know exactly the actual area of the land. It is estimated, however, that the land measures from 50,000,000 to 53,000,000 square miles, or a little more than one-fourth of the earth's surface, the oceans occupying nearly three-fourths.

The greatest height of the mountains above the sea-level is about 29,000 feet. The mean, or average, height of the land is probably about 2200 feet, and the mean depth of the sea is probably as much as 12,000 feet.

2. The larger masses of the land are called **Continents**; the smaller masses are called **Islands.**

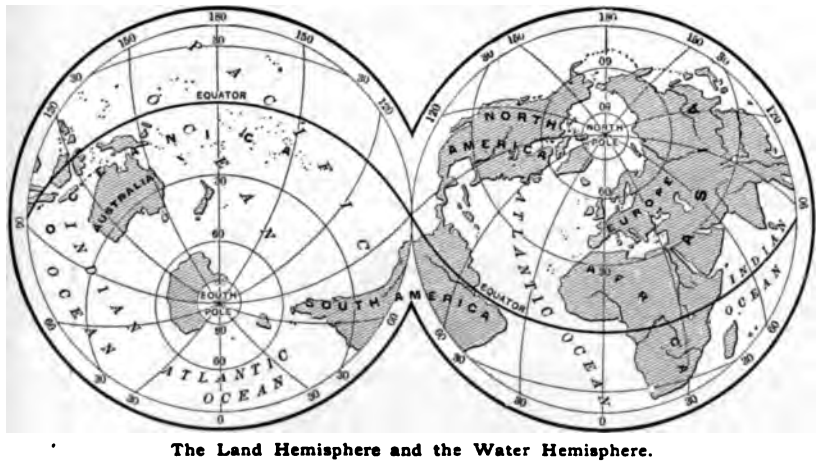
The term **Continent** has been variously used. Formerly geographers described but two continents—the Eastern, which comprised the three "Grand Divisions" of Europe, Asia, and Africa; and the Western, consisting of North America and South America.

With wider knowledge Australia was considered a continent rather than an island, and finally the land around the south pole came to be known as the Antarctic Continent. In popular literature each of the "Grand Divisions" has come to be called a continent, and now most geographers use the word in the same way.

Inasmuch as Europe and Asia form in reality but one great mass of land, some geographers describe both jointly as one continent, for which "Eurasia" and "Euro-Asia" have been suggested as appropriate names.

Thus it happens that all writers do not hold the same opinion as to the use of the term "continent." Some speak of two; others, of three, four, six, or seven.

3. The portions of land—the continents and the islands—are very irregular in shape, and are unequally distributed over the globe. By far the greater portion of the land lies north of the equator.



The Land Hemisphere and the Water Hemisphere.

4. There are also what are called a **Land Hemisphere** and a **Water Hemisphere.** If there should be constructed about the earth an imaginary great circle which should pass through Peru and the Malay Peninsula, and with one of the poles a little south of London in England, this circle would divide the globe into these two hemispheres. One would contain Europe, Asia, Africa, North America, and many large islands. This hemisphere would include six-sevenths of the land, while the other would consist almost entirely of water.

5. The shape of the land-areas may be considered in two aspects—the **Horizontal,** which is the shape more plainly shown on ordinary maps, and the **Vertical,** which represents the relative heights of the parts above the sea-level. The vertical shape is called **Relief.** In order to understand the true shape of the land, both these forms must be studied.

The vertical dimensions of the land are very small as compared with the horizontal. The latter are measured by thousands of miles, and the former by feet. Therefore, on relief maps, and also in sections and in pictures, the vertical dimensions are usually greatly exaggerated as compared with the horizontal.

6. **Horizontal Shapes.**—The continents are, as a rule, broadest toward the north, and the greater land-masses radiate in three directions from the north pole.

If we consider Europe and Asia as two continents, then the six large masses are disposed in three north-and-south pairs, as follows: Europe and Africa; North and South America; Asia and Australia. The outlines of the Antarctic Continent are but imperfectly known, though the chief projections reach northward toward South America and Australia.

The greater land-areas are rudely triangular in shape—North America, South America, and Africa obviously so—with the apex of each pointing southward. Most of the large peninsulas also point southward.

The many attempts made to deduce some law of symmetry which would apply to the shape and distribution of the large land-masses have been unsatisfactory. Irregularity rather than regularity is the most characteristic feature. The forms do not closely repeat themselves, and, owing to this great irregularity of shape and feature, an almost infinite variety of conditions, productions, and scenery exists, and each country has a character of its own. This very variety makes possible the vast number of living species of animals and plants.

It should by no means be inferred from this that the forms are the result of chance ungoverned by law, but rather that the co-operation of various laws and conditions has been so complicated that the resulting shapes are not so symmetrical as they have sometimes been asserted to be.

7. The character of the coast-line has had an important influence on the history and progress of mankind. A coast-line with many indentations has promoted commerce and travel, and has in various ways been a benefit to advancing civilization.

Europe has the greatest length of coast-line in proportion to its area, and it has been the country of the highest intellectual culture. Asia follows next, both in relative length of coast-line and in culture in the previous ages. Then, in order, follow North America, South America, Africa, and Australia; and the indigenous civilization (if we except that of Egypt) has been in about the same order.

Questions.—About what part of the visible surface of the earth is occupied by the land? What is the average height of the land above the level of the sea? The mean depth of the sea? What name is given to large masses of land? What great circle divides the earth into a land and a water hemisphere? In what aspects is the shape of the land considered? Where is the greatest breadth of the continents? What is the approximate shape of the large land masses? Of what importance is the character of the coast-line?

II. Relief.

8. The vertical shape, or **Relief,** of a land-area is manifested in its *mountains*, *table-lands*, *valleys*, and *plains*.

The vertical distance above the sea-level is called the *height*, *elevation*, or *altitude*.

In a general way, lands of less than 1000 feet in height may be designated as *lowlands*, and of more than 1000 feet as *highlands*. The lowlands may consist of plains or rolling hills; the highlands, of mountains or plateaus.

The surface-area of each of the continents is divided into these three great classes—mountains, table-lands, and plains.

The term *relief* is commonly used for the grander and more general features, as regards elevation. The details of the relief of any particular region, taken in connection with the other features, both natural and artificial, such as streams, towns, roads, etc., are embraced in the term *topography*.

9. **Mountains** are steep and narrow elevations of land more than 1000 feet high. Smaller elevations are called *hills*.

Mountains are usually disposed in lines called ranges or chains. As a rule, the chain is a long, continuous ridge with a more or less irregular sky-outline, but sometimes it is a series of elevations in a row—a chain of more or less detached elevations.

Any conspicuous point higher than its surroundings is called a *peak*. The highest edge of a ridge is called its *crest*. The inclines are called the *slopes*, the *sides*, or the *flanks*. The lowest part of the flanks is called the *base*. Depressions or gaps between peaks are called *passes*. In Western North America abrupt isolated peaks or hills are often called *buttes* (pronounced "bewts").

Scenery in the Teton Range of the Rocky Mountains.

10. Mountains may be rudely classified in three groups, according to their structure and the rocks of which they are composed—mountains by *eruption*, by *folding*, and by *fracture*.

Eruptive mountains are those which consist of material which has been thrown out through the crust. The most obvious examples of this class are volcanoes.

Mountains by folding are those in which the stratified rocks are folded or wrinkled with or without breaking. The Appalachian Mountains are illustrations of this type.

Mountains by fracture are those in which the strata have broken as well as tilted, the broken edges of the strata forming one, and usually the steeper, slope of the chain. The Alps are among the best examples of this class.

Most of the mountains of the earth belong to the last two classes. Those which belong to the third class are the most rugged. They are formed by the wrinkling of the crust, and this explains why they are in chains or ridges. All lines of volcanoes are believed to be disposed along great and deep cracks in the crust.

Mountains of two of these classes may usually be found in the different parts of the same chain, and sometimes all three varieties occur. For example, the Cascade Mountains of Oregon have a base of bent strata which cracked at the summit. From this crack the lava poured out, covering most of the sides and forming the crest and all the high peaks.

In most mountains formed by folding, the strata break in places, and there are then some peaks produced by fracture.

The dominating features of relief are due to geological structure. The bends, folds, and cracks of the strata determine the direction and general character of the chains, but all the lesser features and details are due to erosion and denudation. The valleys and gorges are thus formed. The highest peaks are usually of hard rocks which resist denudation, and flat-topped mountains are sometimes produced by having the hard strata remain, while the softer layers beneath are worn away at the edges. The Table Mountains of South Africa and Mount Roraima of South America were formed in this way.

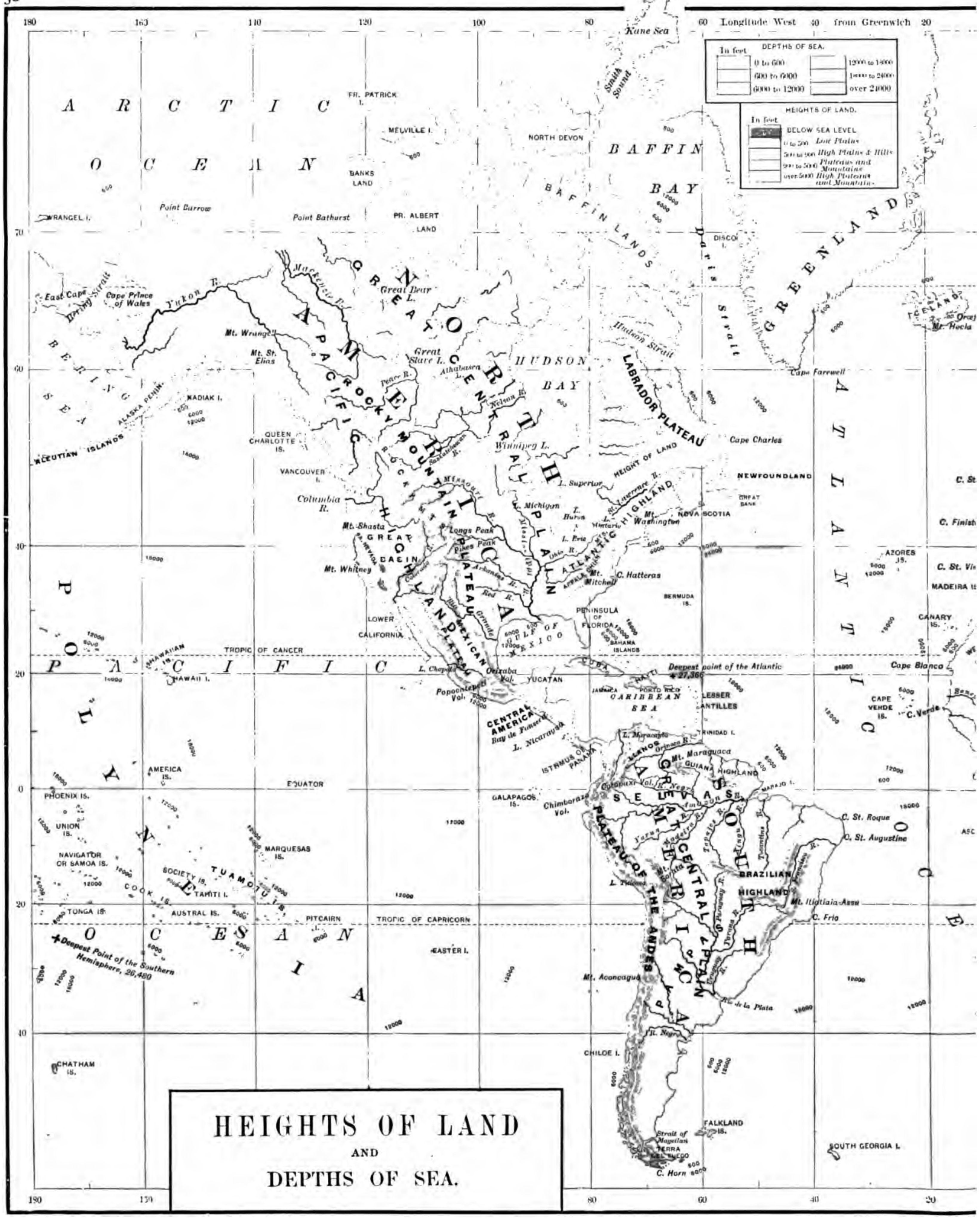
The famous table mountains of California are old lava-streams that once flowed over softer strata. In the course of ages the latter have been denuded, leaving the hard lava as great flat-topped mountains with precipitous sides.

11. **Valleys** are the depressions between mountains or hills. They are called *longitudinal* when they lie between parallel ridges, and *transverse* when they break through a chain or ridge. The former are usually broad and with gentle slopes; the latter, narrow and with steeper sides.

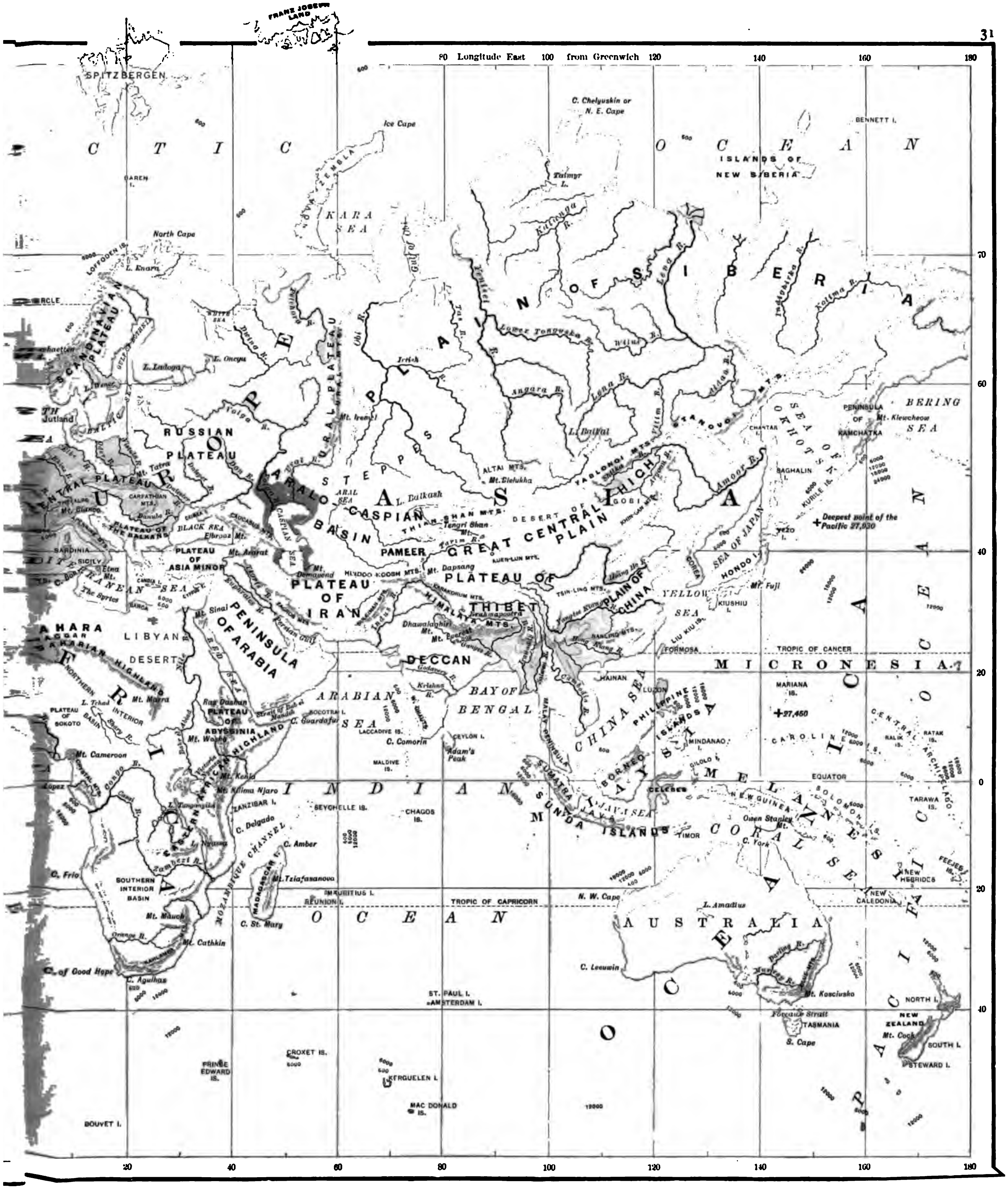
The Shenandoah Valley is a fine example of a longitudinal valley, and the gorge where the Potomac breaks through the Blue Ridge at Harper's Ferry is an instance of a transverse valley. A grander example is where the majestic Columbia River forces its way through the Cascade Mountains.

Certain very narrow gorges are called *cañons* ("can-yons"), some of which are of great depth and sublimity. The most remarkable in the world are those of the Colorado River, which have been eroded to the depth of from 4000 to 7000 feet in the rocky plateaus of Utah and Arizona.

12. A **Mountain-System** includes several mountain-chains and their intervening valleys, all related to one another by some common feature. For example, the Appalachian System of Eastern North America is composed of many parallel ranges and ridges which represent separate folds or wrinkles of the strata. The various ridges or groups take separate names, as the Cumberland, Blue Ridge, Catskills, Green Mountains, etc., all forming one system.



HEIGHTS OF LAND AND DEPTHS OF SEA.


FRANZ JOSEPH LAND
SPITZBERGEN
Longitude East from Greenwich
C. Chelyuskin or N. E. Cape
Ice Cape
BENNETT I.
C T I C
O C E A N
ISLANDS OF NEW SIBERIA
Taimyr L.
BAREN I.
KARA SEA
North Cape
LOFFODEN IS.
L. Enara
SCANDINAVIAN PLATEAU
WHITE SEA
L. Ladoga
L. Onega
Jutland
RUSSIAN PLATEAU
URAL PLATEAU
Mt. Iremel
E U R O P E
PLAIN OF SIBERIA
Yenisei R.
Lena R.
Lower Tunguska R.
Angara R.
Irtish R.
Obi R.
L. Baikal
STANOVOI MTS.
SEA OF OKHOTSK
BERING SEA
PENINSULA OF KAMCHATKA
Mt. Klewchewa
SAGHALIN I.
KURILE IS.
Amoor R.
ALTAI MTS.
Mt. Bielukha
STEPPES
L. Balkash
ARAL SEA
ARALO-CASPIAN BASIN
CASPIAN SEA
CARPATHIAN MTS.
CENTRAL PLATEAU
Mt. Tatra
PLATEAU OF THE BALKANS
BLACK SEA
CAUCASUS MTS.
Elbruz Mt.
Mt. Ararat
PLATEAU OF ASIA MINOR
SARDINIA
SICILY
Mt. Etna
MEDITERRANEAN SEA
The Syrtes
THIAN-SHAN MTS.
Tengri Shan Mt.
DESERT OF GOBI
TABLONOI MTS.
KHIN-GAN MTS.
GREAT CENTRAL PLAIN
HIGH ASIA
PAMEER
HINDOO KOOSH MTS.
Mt. Dapsang
KUEN-LUN MTS.
PLATEAU OF THIBET
Mt. Demavend
PLATEAU OF IRAN
HIMALAYA MTS.
Dhawalaghiri Mt.
Mt. Everest
Ganges R.
Brahmaputra R.
TSIN-LING MTS.
PLAIN OF CHINA
Yangtse Kiang R.
NANLING MTS.
YELLOW SEA
COREA
SEA OF JAPAN
HONDO I.
Mt. Fuji
KIUSHIU I.
LIU KIU IS.
FORMOSA
YEZO I.
Deepest point of the Pacific 27,930
TROPIC OF CANCER
MICRONESIA
MARIANA IS.
+27,460
CAROLINE IS.
CENTRAL ARCHIPELAGO
RALIK IS.
RATAK IS.
TARAWA IS.
SAHARA
LIBYAN DESERT
NORTHERN HIGHLANDS
Mt. Marra
L. Tchad
PLATEAU OF SOKOTO
INTERIOR BASIN
Mt. Cameroon
Congo R.
Mt. Sinai
PENINSULA OF ARABIA
RED SEA
Persian Gulf
Ras Dashan
PLATEAU OF ABYSSINIA
Mt. Woche
EASTERN AFRICAN HIGHLAND
Mt. Kenia
Mt. Kilima Njaro
ZANZIBAR I.
L. Tanganyika
L. Nyassa
Zambezi R.
C. Delgado
MOZAMBIQUE CHANNEL
MADAGASCAR I.
Mt. Tsiafasanova
C. Amber
C. St. Mary
SOCOTRA I.
C. Guardafui
ARABIAN SEA
LACCADIVE IS.
C. Comorin
MALDIVE IS.
DECCAN
Godavery R.
Krishna R.
BAY OF BENGAL
CEYLON I.
Adam's Peak
HAINAN
LUZON
PHILIPPINE ISLANDS
MINDANAO I.
CHINA SEA
MALAY PENINSULA
SUMATRA I.
BORNEO
CELEBES
MALAYSIA
JAVA SEA
SUNDA ISLANDS
TIMOR
GILOLO I.
NEW GUINEA
Owen Stanley Mt.
MELANESIA
SOLOMON IS.
C. York
CORAL SEA
NEW HEBRIDES
FEEJEE IS.
NEW CALEDONIA
EQUATOR
I N D I A N
SEYCHELLE IS.
CHAGOS IS.
C. Frio
SOUTHERN INTERIOR BASIN
Mt. Mauch
Orange R.
Mt. Cathkin
C. of Good Hope
C. Agulhas
MAURITIUS I.
REUNION I.
TROPIC OF CAPRICORN
O C E A N
N. W. Cape
L. Amadeus
AUSTRALIA
Darling R.
Murray R.
Mt. Kosciusko
C. Leeuwin
Foveaux Strait
TASMANIA
S. Cape
NORTH I.
NEW ZEALAND
Mt. Cook
SOUTH I.
STEWARD I.
OCEANICA
PACIFIC
ST. PAUL I.
AMSTERDAM I.
CROXET IS.
PRINCE EDWARD IS.
KERGUELEN I.
MAC DONALD IS.
BOUVET I.

13. **Table-Lands** or **Plateaus** are broad elevations of more than 1000 feet in altitude. They are all elevations in mass, while mountains are elevations in line.

The transition from low plains to plateaus is often so gradual as to be imperceptible to the eye unless aided by actual measurements. The Great Plains west of the Mississippi rise from a few hundred feet in height near the river to about 5000 feet at the base of the Rocky Mountains, and form, in fact, a gently-inclined plane with nothing to mark the transition from low plain to plateau. Other plateaus have abrupt slopes—as, for instance, that of Mexico or Anahuac; still others are enclosed by mountain-chains which rise upon their margins.

Plateaus are sometimes nearly level—as, for example, South Park, in Colorado—but they are more frequently rough, and they generally have a diversified surface, often furrowed with deep cañons, like the plateau of Northern Arizona, and sometimes traversed by superimposed mountains, like those of Utah and Nevada.

Plateaus have a dry climate and a soil usually rather sterile, and are for the most part without forests, but have a scattered growth of trees.

In Mexico and the Western United States the terms *table* and *mesa* (Spanish for "table") are often applied to natural terraces which are old lake-shores now above a valley, or to other somewhat elevated portions of land, to distinguish them from lower, or valley, land. These "tables" are not to be confounded with geographical features described as "table-lands." The **Parks** of the Rocky and other Western mountains are limited plateaus enclosed in the mountains. They are grassy and have usually some scattered trees, and are often of great beauty.

14. **Low Plains** are below 1000 feet in altitude, and are either level or diversified with gently-rolling hills. The lowest plains are generally the most level.

Plains are of various kinds as to origin, fertility, vegetation, and aspect, and have taken a variety of names in different countries.

Alluvial plains, like those of the delta of the Mississippi, the Ganges, or the Nile, are formed by the sediment brought down by rivers, and are mostly low, level, fertile lands interspersed with swamps and shallow lagoons. The ***prairies*** of North America are grassy, fertile plains either level or with long rolling swells. In the warmer parts of America certain plains which can be used for pasture only during the wet season are called ***savannas***. In South America certain grassy plains more or less fertile are called ***pampas***, and others ***llanos***, and the forest-covered plains are known as ***selvas***. In Northern Europe low and somewhat sandy plains clothed to some extent with low flowering shrubs and heather are called ***heaths***. The term ***marine plains*** is often applied to the more or less sandy plains between the mountains and the sea. These may be barren or they may be moderately fertile, like those of the Eastern United States. The ***steppes*** of Southern Russia and Western Asia are rather barren plains with scanty herbage and with flowering shrubs, some of which are tall. The ***tundras*** of Siberia are extensive frozen swamps the surface of which thaws in summer to a slight depth, and supports a dense growth of moss and other low Arctic vegetation.

The most fertile lands of the globe are plains, and they support the most dense populations, as in China, India, The Netherlands, etc. Some plains are not particularly productive, and others may be found of every degree of fertility down to absolute barrenness.

Questions.—What is relief? How is it manifested? What are highlands and lowlands? Into what three classes is the surface of the continents divided? What is topography? In what three groups are mountains classified? To what causes are the features of relief due? How are table-mountains formed? What is a valley? How do longitudinal and transverse valleys differ? What is a cañon? What is a mountain-system? What is a table-land or plateau? What is usually the character of the surface of a plateau? What is a low plain? What is meant by the term "alluvial plain"? What is a prairie? What are savannas? Pampas? Llanos? Selvas? Heaths? Marine plains? Steppes? Tundras? Where are the most dense populations of the world found?

III. The Continents.

15. Each of the continents has all of the great forms of relief, and contains:

a. A predominant or primary mountain-system exceeding all the others in extent and height.

b. One or more secondary mountain-systems.

c. Several low plains. The plateaus are contiguous to the mountain-systems, or enclosed within them between the separate ranges.

As a rule, the predominant or highest mountain-system is near one side of the continent and faces the greatest of the surrounding oceans.

The distinction between continents and islands is arbitrary, and is founded partly on size and partly on relief. It may be said, in a general way, that islands are small, have but one mountain-system, and are highest in the middle, while continents are larger and have two or more mountain-systems with extensive plains or plateaus between them.

Each continent has a peculiar individuality as to aspect and character, due to the great difference in the shape and arrangement of its component parts. For example, the two American mountain-systems each run north and south, with great and continuous plains between them; yet they differ greatly in their details.

Africa and Australia have their chief mountain-systems also running north and south, but they have great plateaus between them, and they have, moreover, small and narrow plains, which are on the coast.

In Europe and Asia the greater chains have an easterly-and-westerly direction. The mountain-systems are vastly more complicated, and there are extensive plains in the northern part of each of these divisions.

IV. North America.

16. **North America** is the third continent with reference to size, and the predominant mountain-system occupies all the western part for its entire length—a distance of 5700 miles. This system is known as the **Cordilleras of North America**, or sometimes as the **Pacific System**, and is part of that greater system which extends from Cape Horn to the Arctic Ocean, the greatest mountain-system of the globe in all respects except height.

The North American portion may be considered in four parts:

a. From the **Isthmus of Panama** to that of **Tehuantepec.** The distance is about 1450 miles, of which the greater part is occupied by the Plateaus of Central America and Yucatan. At the Isthmus of Panama the land in the narrowest part is scarcely 30 miles wide, and the mountains are from 3000 to 6000 feet high. The passes between the mountains are at a height of from 260 to 300 feet above the level of the sea. The lowest pass is at Nicaragua, and is 151 feet above the sea-level. The Plateau of Central America is highest along its western part, where there are many volcanoes, active and extinct. The highest of these volcanoes reach an altitude of more than 12,000 feet.

b. In **Mexico.** At the Isthmus of Tehuantepec the land is 130 miles wide and the crest about 800 feet above the sea. North of this the mountains become higher again and spread out like the ribs of a fan, between which lie plateaus with an altitude varying from 3000 to 8000 feet. The high peaks are all volcanoes. **Orizaba** (18,314 feet) and Popocatepetl (17,784 feet) are the highest.

SECTION ALONG THE ROCKY MTS. AND THE SIERRA MADRE FROM NORTH WEST TO SOUTH EAST.

c. In the **United States.** The chains continue to spread, the system attaining its greatest width at about lat. 40°, where it is more than 1000 miles wide and the broadest mountain-system of the globe. The term **Rocky Mountains** is used in speaking of the eastern chains. These are highest in Colorado, where there are nearly forty peaks between 14,000 and 14,500 feet high. The higher western chains are the **Sierra Nevada** and its continuation the **Cascade Range.** The highest peaks of the Sierra Nevada are in the western part. Mount Whitney is 14,898 feet in height. All the higher peaks north of lat. 40° are extinct volcanoes, of which Mount Shasta (14,440 to 14,500 feet) and Mount Tacoma or Rainier (14,444 feet) are the highest. Between these and the sea are the various chains of the "Coast Ranges," of which the highest peaks have an altitude of 8000 or 9000 feet.

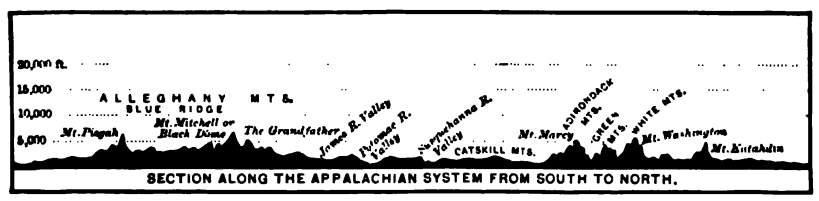
Between the Rocky Mountains and the Sierra Nevada are numerous parallel ridges with peaks from 5000 to 12,500 feet in height, enclosing plateaus from 4000 to 11,000 feet high. There are in the southern part some low valleys, of which Death Valley, in California, is nearly 300 feet below the level of the sea. The Sink of San Felipe, near the mouth of the Colorado River, and in reality a continuation of the same depression, is even lower. The Peninsula of Lower California is in line with the Sierra Nevada.

Relief Map of North America.

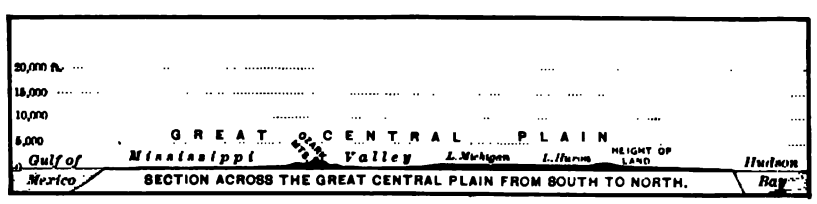
d. In **British America.** The peaks are non-volcanic, the mountains more rugged, the highest peaks 13,000 or 14,000 feet above sea-level. The system narrows as it extends northward. In Alaska the extinct volcano of Mount St. Elias, situated on the boundary-line, is estimated to be 18,010 feet in height, and other peaks from 16,000 to 18,000 feet. This volcanic chain curves westward through the Peninsula of **Alaska,** and is continued in the Aleutian Islands.

17. The **Secondary Systems** of North America occupy only a part of the eastern side. They are:

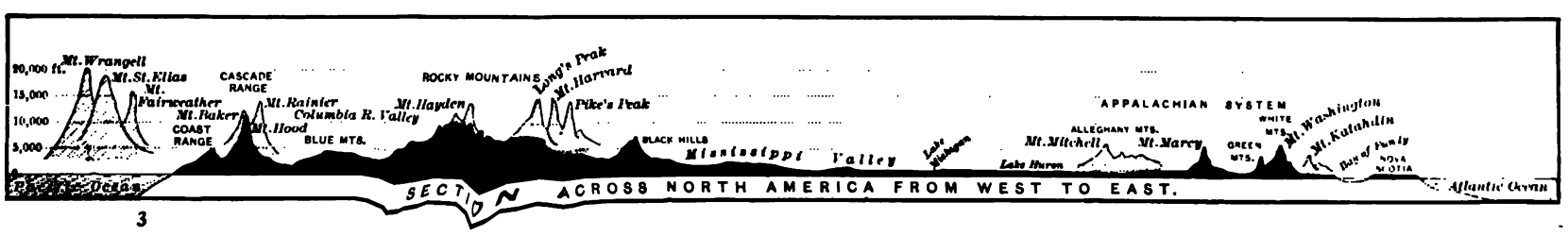
a. The **Appalachian System,** which extends from the St. Lawrence to Northern Georgia and Alabama. In the north it consists of groups, of which the White Mountains (Mount Washington, 6288 feet), the Green Mountains (Mount Mansfield, 4430 feet), the Adirondacks (Mount Marcy, 5403 feet), and the Catskills (4000 feet) are the most important. Between these groups are the gaps or passes of the Connecticut River Valley and the valleys of Lake Champlain and the Mohawk and Hudson rivers, of great importance to commerce. South of the Mohawk Valley there are no continuous passes through this system, and it consists of parallel ridges, most numerous in Pennsylvania. Some of the longitudinal valleys between these ridges are of great beauty and fertility. The peaks become higher again in North Carolina (Mount Mitchell, 6688 feet).



SECTION ALONG THE APPALACHIAN SYSTEM FROM SOUTH TO NORTH.



SECTION ACROSS THE GREAT CENTRAL PLAIN FROM SOUTH TO NORTH.



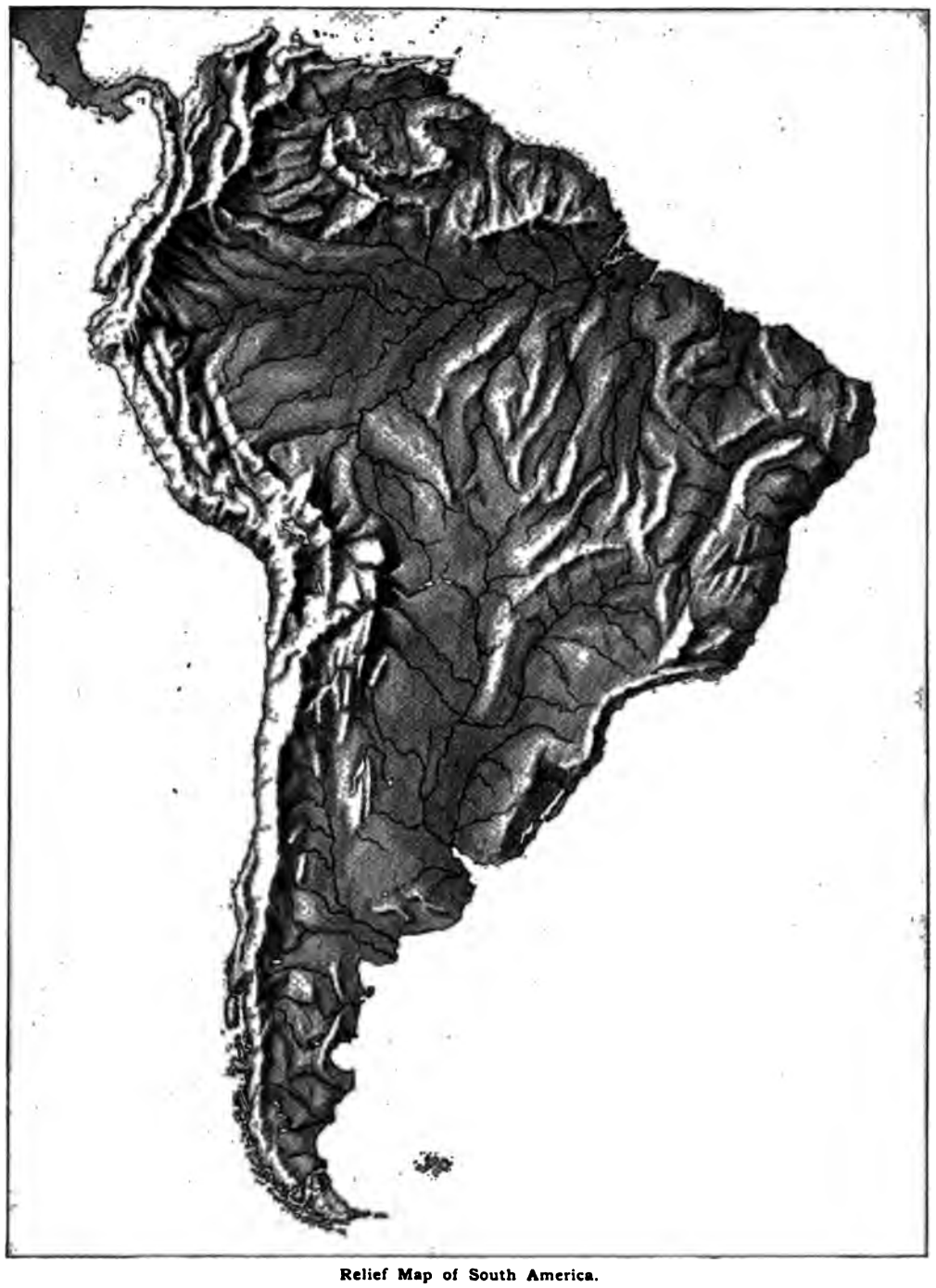
SECTION ACROSS NORTH AMERICA FROM WEST TO EAST.

b. **The Laurentian, or Laurentide, Mountains.**—Between the St. Lawrence and Hudson Bay are broad, low, rounded elevations, generally below 2000 feet in height, only the highest points reaching an altitude of 4000 feet. On the northeast the system is continuous with the Plateau of Labrador, and west of Hudson Bay it follows the direction of the Arctic Plateau.

18. **Low Plains.**—Between the primary and secondary mountain-systems plains extend continuously from the Gulf of Mexico to the Arctic Ocean, and pass imperceptibly to the plateaus which extend eastward from the Rocky Mountains. The "*Height of Land*," which separates the northern and southern portions, is not a mountain-chain, but a gentle swell of land which, rising imperceptibly from the plain, becomes a plateau in its altitude above the sea, but in no other feature.

Plains lie between the Appalachian Mountains and the sea, extending southward to Florida and the Gulf of Mexico, where they become continuous with the great inland plain.

Questions.—What forms of relief are to be found in each of the continents? Near which side is the predominant mountain-system usually situated? How does an island differ from a continent? What difference is observed in the aspect of the different continents? What is the relative size of North America? What is the principal mountain-system? How is it divided? Describe the first part. What is the character of the system in Mexico? Describe the Rocky Mountains and the Sierra Nevada and Cascade Range. Where are valleys found which are below the sea-level? What is said of the system in British America and Alaska? What is the character of the mountains in the Peninsula of Alaska and in the Aleutian Islands? Where are the secondary systems? What is said of the Appalachian System? Of the Laurentian Mountains? Where are the low plains? How is the inland plain divided?



Relief Map of South America.

V. South America.

19. **South America** is the fourth continent in size, and strikingly resembles North America in the arrangement of its relief-forms. It has, like the latter, a predominant mountain-system in the west, two secondary systems in the east, and three low plains intervening.

The predominant mountain-system is called the **Andes,** and trends from the Strait of Magellan to the Isthmus of Panama, forming an unbroken mountain-wall.

The divisions of the Andes receive the names of the States and countries which include them.

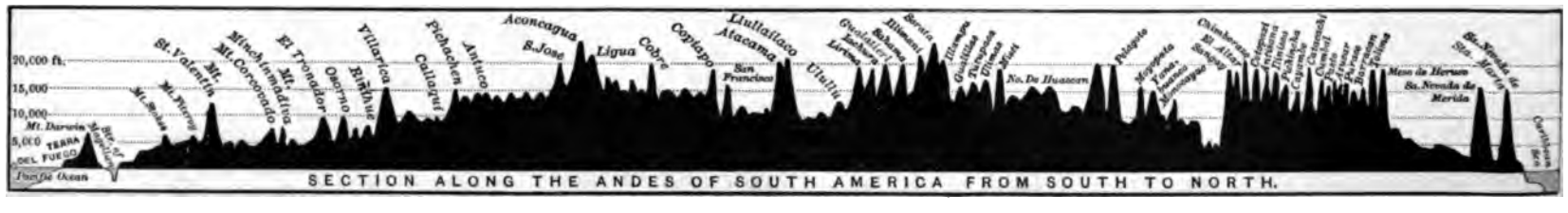
a. The **Andes of Patagonia** are narrow, with peaks of moderate elevation, and with glaciers that descend to the sea.

b. The **Andes of Chili,** from the volcano Ozurno to 25° south latitude, form also a single lofty chain (12,000 feet mean height), which bears three distinct crests.

c. The **Andes of Bolivia and Peru,** from 25° to 5° south latitude, consist also of two chains, which enclose the Plateau of Bolivia, 12,900 feet above the sea-level.

Northwest of Lake Titicaca the chains are connected by the great mountain-group or knot of Cuzco. From this mountain-knot spring three chains, which trend northwest. Between the eastern and the western is the valley of the upper Amazon River, or the Plateau of Caxamarca, over 9000 feet high.

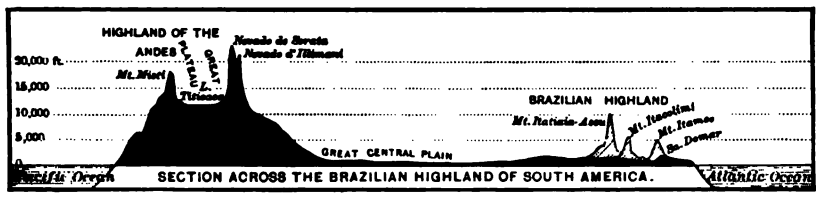
d. The **Andes of Ecuador and Colombia** trend from the Amazon to the north-northeast in two chains, which are repeatedly connected by mountain-knots and enclose a series of high plateaus. The equator passes across the Plateau of Quito, 9545 feet high. From the most northern mountain-knot—



SECTION ALONG THE ANDES OF SOUTH AMERICA FROM SOUTH TO NORTH.

that of Los Pastos—branch off three diverging chains, which are separated by the valleys of the Cauca and Magdalena rivers.

20. **The Secondary Systems.**—The two secondary systems of South America lie in the eastern part of the continent.



a. The **Table-Land of Brazil,** 1,000,000 square miles in extent, has a mean elevation of about 2500 feet; but upon its wide area rise numerous nearly parallel mountain-chains having some peaks which are from 5000 to 10,000 feet high.

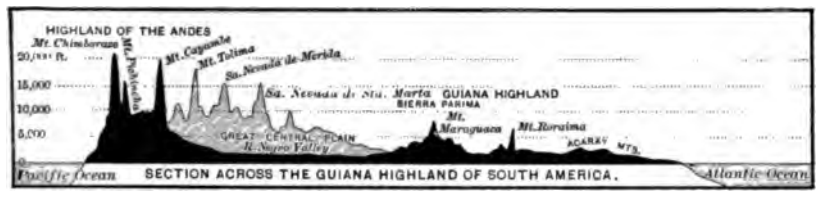
The various ranges which traverse this plateau-region are approximately parallel to the Atlantic coast. The loftiest peak is Mount Itatiaia-Assu, which is 10,040 feet high.

b. The **Plateau of Guiana** is smaller, but higher, than the preceding. It is also crossed by many mountain-chains, which are as yet but partially explored.

Among the mountains of this section, the most remarkable are Mount Roraima and Mount Twek-kway. Both are flat-topped and have vertical sides surmounting a long slope of fragmentary rocks stretching from the foot of the precipice to the savanna country below. Mount Roraima, the higher of the two mountains, is about 8000 feet in height and destitute of trees.

21. **The Low Plains.**—South America has three vast low plains connected in a continuous belt.

a. The **Llanos of the Orinoco,** between the coast-ranges of Venezuela and the Plateau of Guiana, are 270,000 square miles in extent. During the rainy season they are covered with grasses and herbs; during the dry season they resemble a desert.



b. The **Selvas,** or **Forests of the Amazon,** lie between the Plateau of Guiana and the Table-land of Brazil, and reach from the foot of the Andes to the Atlantic Ocean. They consist throughout of the most luxuriant tropical forests. This plain is nearly 3,000,000 square miles in extent.

c. The **Pampas of the La Plata,** between the Table-land of Brazil and the Andes, extend into Patagonia.

Questions.—What is the relative size of South America? What continent does it resemble in the arrangement of its relief-forms? What is the predominant mountain-system called? Of what other system is this a continuation? What peak at the southern extremity of this system? Describe the Andes of Patagonia. What is the mean height of the chain in Chili? Describe the Andes in Peru and Bolivia. In Ecuador and Colombia. What are the secondary systems? Is the Brazilian Plateau extensive? Name the highest peak in that section. What remarkable mountains form part of the Highland of Guiana? Where are the Llanos? The Selvas? The Pampas?

VI. Europe.

22. The relief-forms of Europe are vastly more complicated than those of either the Americas, Africa, or Australia. The general trend of the greatest mountain-chains is east and west, but the earth's crust has here been so crumpled that ranges may be found extending toward any point of the compass.

This complexity of structure produces many valleys and basins enclosed by mountains and favorable for the existence of many small separate and independent nations. This feature has played a most interesting part in European history.

To this complexity of structure are also due the extended coast-line and the many indentations and peninsulas.

23. The **Alps** are the predominant mountain-system. From the Gulf of the Lion, on the Mediterranean Sea, they sweep in a curve northward and eastward, and are connected with numerous lower chains, which ramify northward into Germany, southward into Italy, and eastward to the Black Sea, Turkey, and Greece. The highest peaks are Mont Blanc (15,811 feet) and Monte Rosa (15,208 feet).

The Alps proper extend only through Switzerland and the Tyrol, and consist of three or more parallel ranges which are connected in places. The height and grandeur of the peaks, the amount of perpetual snow, the number, extent, and sublimity of the glaciers, the fertile and picturesque valleys, with their many villages, make a combination of scenery of unsurpassed beauty.

24. **The Secondary Systems.**—These surround the Alps on the east, north, and west sides, consisting of a large number of chains, groups, and low plateaus more or less divided by valleys.

a. The **French Mountains** lie west of the Alps, and are separated from them by the plain of the Rhone River. They extend from the lowland of Southern France to the Rhine, bearing different local names, as Cévennes Mountains, Lyonnais Mountains, Vosges Mountains, etc. The Plateau of Auvergne, rich in extinct craters and volcanic forms, lies west of the Lyonnais Mountains.

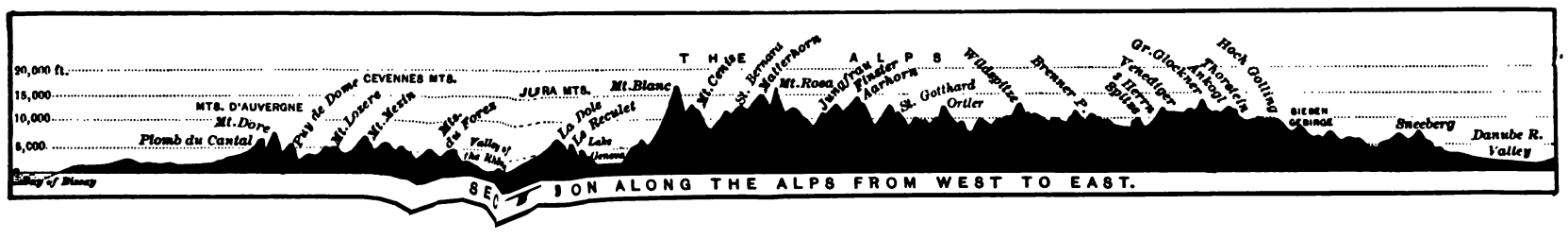
b. The **German Mountains** extend from the Rhine to the Oder River. The Swiss and Bavarian plateaus connect this section with the Alps. The Swiss and Swabian Jura, the Rhenish Mountains with their vine-clad slopes and picturesque scenery, the Hartz Mountains, and the Sudetes are the principal chains.

c. The **Hungarian Mountains** extend from the Oder River southeastward to the Danube. The Carpathians, in the west, are the highest group, the Transylvanian Mountains lie in the east, and the Hungarian Forest Mountains connect the two.

Besides the secondary mountains above described, there are others in the great peninsulas and islands.

d. The Turkish peninsula is almost entirely filled with mountains. The Dinaric Alps trend along the shore of the Adriatic and are connected with the Alps proper. The Balkans traverse the peninsula from west to east; the Pindus Mountains, from north to south.

e. The Italian peninsula is traversed by the Apennines, which are connected with the West Alps, and terminate at the Strait of Messina, leaving but few small plains, as the Roman Campagna and the Plain of Naples. In the latter stands the volcano Vesuvius. Sicily is also mountainous. The highest elevation is the volcano Etna, 10,674 feet.



Relief Map of Europe.

f. The Spanish peninsula is a large plateau upon which rise several mountain-chains, all trending from east to west. The Pyrenees and Cantabrian Mountains are in the north; the Sierra Nevada, in the south. The highest peak of the Pyrenees is 11,168 feet high.

g. The Scandinavian peninsula forms a low plain in the east and a high and rugged plateau in the west which descends in steep slopes to the shore.

h. The northern and western parts of Great Britain are mountainous; the southern and eastern parts, low and undulating. In the north are the Scottish Highlands, the Grampian Hills; farther south, the Cheviot Hills, the Cumbrian Hills, and the mountains of Wales. Ireland is mainly low and level; a few mountain-groups lie near the sea-shore.

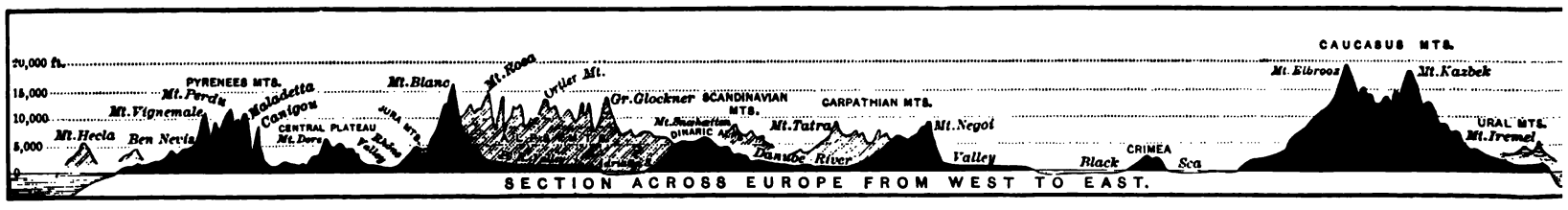
i. The Ural Mountains, of moderate height, separate the plains of Northern Europe from those of Asia, and between the Black and Caspian seas the boundary is formed by the higher Caucasus Mountains, of which Elbrooz (18,493 feet) is the highest peak.

25. The **Plateaus** of Europe are of limited extent and of mo erate height. The most important are those of Spain, of Wurte berg and Bavaria, and that of Transylvania, in Eastern Hungary.

26. **The Low Plains.**—Almost the entire northern part of E rope is a vast low plain diversified only by hills and undulatio This plain embraces nearly the whole of Russia, the north Germany, Holland and Belgium (in part), and Western France.

A number of small plains lie within the mountain-region, as the Plain of t Rhone River; the Hungarian Plain; the Wallachian Plain, near the Black Se the Plain of the Middle Rhine, between the Vosges Mountains and the Bla Forest; the Plain of the Po River, south of the Alps, separating them from t Apennines. There are many small basins, like those of Moravia, Bohem Franconia, etc., which may be considered as enclosed plains.

Questions.—What is the character of the relief of Europe? What is the direction the greatest mountain-chain? Describe the Alps. What secondary systems in Franc In Germany? In Hungary? What mountains fill the Turkish peninsula? The Italia The Spanish? What is the character of relief in the Scandinavian peninsula? In Gr Britain? Where are the plateaus? The plains?



Relief Map of Asia.

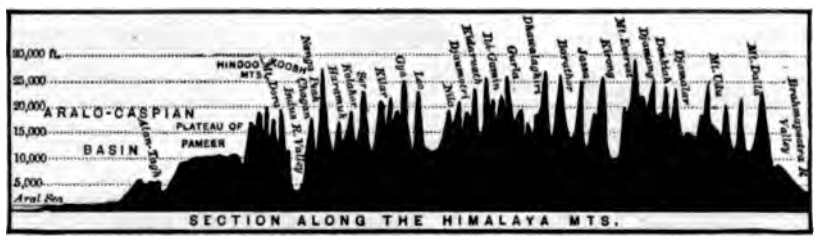
VII. Asia.

27. As North America and South America resemble each other in the arrangement of their form of relief, so do Europe and Asia. In both the predominant systems are in the south, surrounded on three sides by the secondary systems, while the great low plains lie near the outline of the continent.

But as Asia is the largest of the continents, so also are its mountains the highest and its plateaus the most massive in elevation and extent.

The predominant system is the great **Plateau of Thibet,** with its mountain-barriers, the Himalaya, Karakorum, Kuen-Lun, and Yungling Mountains.

The average elevation of Thibet is 14,000 feet—*i. e.*, nearly equal to that of the highest peaks in the Rocky Mountains—and its area is 250,000 square miles.



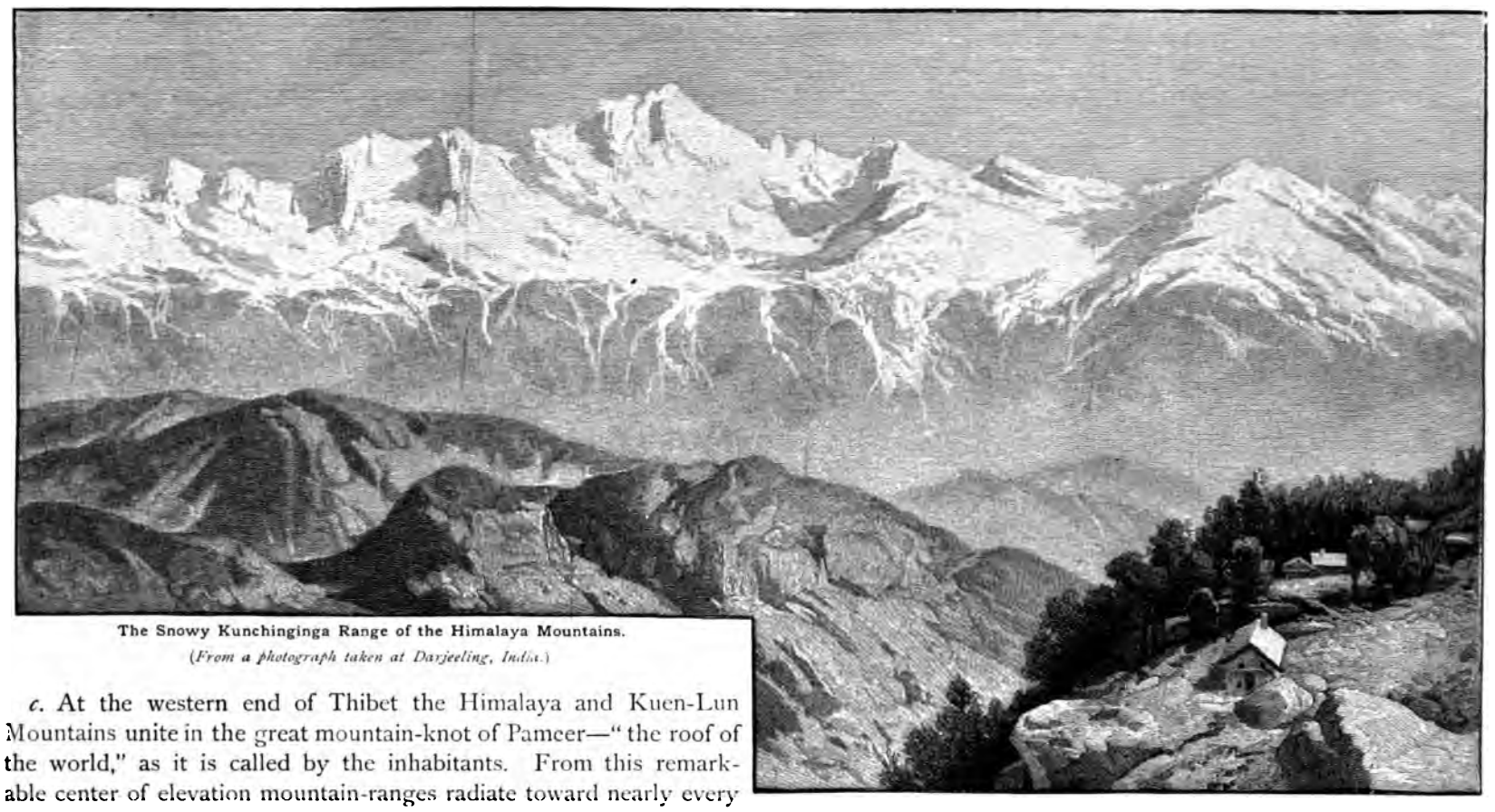
The Himalaya Mountains rise upon its southern border, sloping abruptly from an elevation of 18,000 feet down to the tropical low plains of the Ganges.

Mount Everest (29,002 feet), Kunchinginga (28,158 feet)—the highest mountains in the world—are two of the colossal mountain-peaks which crown the crest. The Karakorum and Kuen-Lun chains trend east and west, and are nearly as high as the Himalaya. The Kuen-Lun Mountains bound Thibet on the north.

28. **The Secondary Systems.**—*a.* North of the Kuen-Lun extend the arid plateaus of the Tarim River—only 2000 feet high—and north and east of this the Mongolian Plateau. In the west the high Thian-Shan ranges separate them; in the east they form the desert steppe of Gobi.

The Mongolian Plateau, including the Gobi, is bounded on the north by the Altai Mountains and on the east by the Great Khingan Mountains.

b. Several chains of high mountains extend from the Plateau of Thibet to the east, as the Peling and Nanling in China and the various ranges that traverse the peninsula of Indo-China, which decrease in elevation as they extend southward and terminate in the Malay Peninsula.



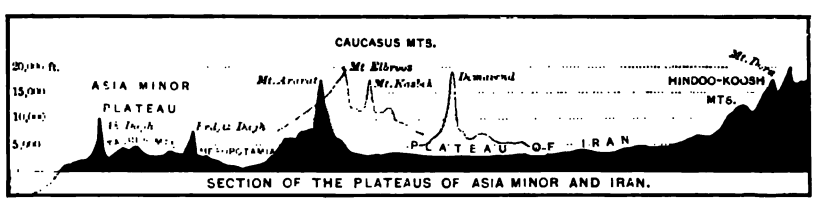
The Snowy Kunchinginga Range of the Himalaya Mountains.
(*From a photograph taken at Darjeeling, India.*)

c. At the western end of Thibet the Himalaya and Kuen-Lun Mountains unite in the great mountain-knot of Pameer—"the roof of the world," as it is called by the inhabitants. From this remarkable center of elevation mountain-ranges radiate toward nearly every point of the compass.

The Hindoo-Koosh Mountains extend to the westward from the Pameer, and form the connecting-link between Thibet and the plateaus and mountains of Western Asia.

d. The Plateau of Iran is bounded on the north by the Elburz Mountains, on the south and west by the Zagros Mountains, and on the east by the Suleiman Mountains. It has an average elevation of about 5000 feet and is principally a desert region abounding in salt steppes, though some of the valleys among the mountains are well watered and fertile. The mountain-region of Armenia lies west of Iran; the extinct volcano Mount Ararat (17,260 feet) is the highest peak. The Plateau of Asia Minor occupies the peninsula of the same name, and is traversed by the Taurus Mountains. There is a greater rainfall than on the Plateau of Iran, and the soil is more productive.

e. The Arabian peninsula is a plateau with a small, well-watered and fertile mountainous tract in the interior and with narrow coast-plains, some of which are fertile, but the greater part of the plateau is a hot, dry desert. In the peninsula of Hindoostan lies the Plateau of Deccan, with an average altitude of about 1000 feet. It is bordered by the Vindhya Mountains and the Eastern and Western Ghauts.



SECTION OF THE PLATEAUS OF ASIA MINOR AND IRAN.

29. **The Low Plains.**—*a.* The Plain of Siberia and Turkestan occupies the northern and northwestern part of Asia. It extends from the Caspian Sea to the Arctic Ocean. The region around the Aral and Caspian seas belongs to the great depression which extends into Europe, and which is below the level of the sea.

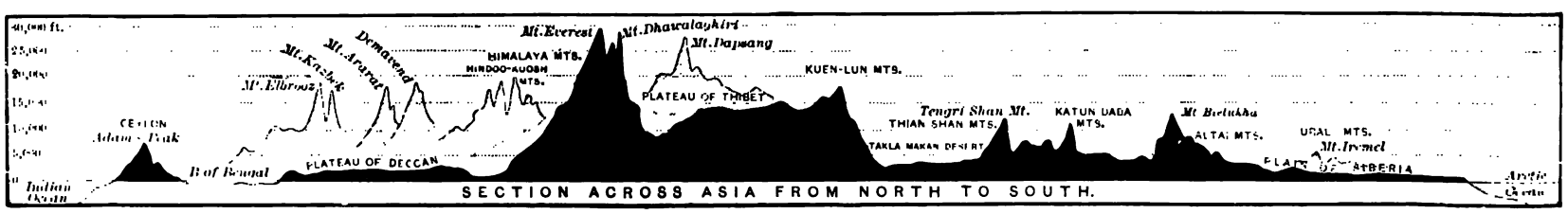
b. The Plain of the Amoor River is surrounded by the mountains of Mantchooria.

c. The Plain of China lies upon the lower courses of the Hoang-Ho and Yang-tse-Kiang. It is well watered, very fertile, and highly cultivated, and supports a larger population than any other region of the globe of equal size.

d. The Plain of Hindoostan lies between the Himalaya Mountains and the Plateau of Deccan. It is traversed by the Ganges and Indus rivers, and is very densely populated.

e. The Plain of the Euphrates and Tigris rivers extends between the Plateaus of Iran and Arabia. It is the Mesopotamia of the Bible. The ancient empires of Assyria and Babylonia flourished in this fertile region, but at present the indolent inhabitants neglect irrigation, and the country resembles a desert.

Questions.— What continent resembles Asia in arrangement of relief? What is the predominant system? What is the average elevation of the Plateau of Thibet? What is said of the height of the Himalayas? What secondary systems are north of the Kuen-Lun Mountains? What chains east of the Plateau of Thibet? Where is the Pameer? What mountains extend westward from this point? What plateaus are still farther west? What plateau in Hindoostan? What plain in the north and northwest? Where is the Plain of the Amoor River? Of China? Of Hindoostan? What plain is noted in sacred history?



SECTION ACROSS ASIA FROM NORTH TO SOUTH.

VIII. Africa.

30. The whole continent is a moderately-elevated plateau surrounded on all sides by marginal mountains which either slope abruptly down to the sea or leave narrow coast-plains.

In Southern and Northwestern Africa the mountain-ranges have an easterly-and-westerly direction; in Eastern and Southwestern Africa, a northerly-and-southerly direction.

The plateau is lowest in the interior, and gradually rises toward the margins. Lake Tchad in the Soudan, and Lake Ngami in South Africa, occupy two of the low interior depressions.

To the northeast of Lake Tchad lies a still lower depression, which at high water receives the overflow of Tchad.

The mountains of the eastern side may be considered the predominant system; the others, secondary systems.

The **Eastern Highlands** begin near the Red Sea and extend southward across Abyssinia to Zanzibar. Mt. Kenia (over 17,000 feet), Kilima Njaro (19,680 feet), and Mt. Ruwenzori are the highest peaks. Farther south are the Lupata Mountains and other chains.

31. **The Secondary Systems.**—The southern margin of the African plateau is formed by the ranges of the Kahlamba Mountains; the western, by several chains, as the Crystal Mountains and others. The Cameroon Mountains are an isolated group of small extent, but of great height (13,000 feet), rising abruptly from the Bight of Biafra.

In Northern Africa are two important groups—the Kong Mountains (scarcely 3000 feet), north of the Gulf of Guinea, and the Atlas Mountains, near the Mediterranean Sea, with peaks 12,000 feet in height.

32. The interior of Africa consists of at least four distinctly-marked regions.

Relief Map of Africa.

a. **The Great Desert of Sahara,** of over 2,500,000 square miles, and the largest desert of the globe. It is, in the main, a plateau, lower at the ends and higher in the middle, where there are some rocky mountain-ranges 7000 feet high. The surface is partially sandy and partially rocky. At some points the surface of the Sahara is below the level of the sea.

The oases are limited areas, lower than the surrounding desert, where springs of water make habitable spots amid the general desolation.

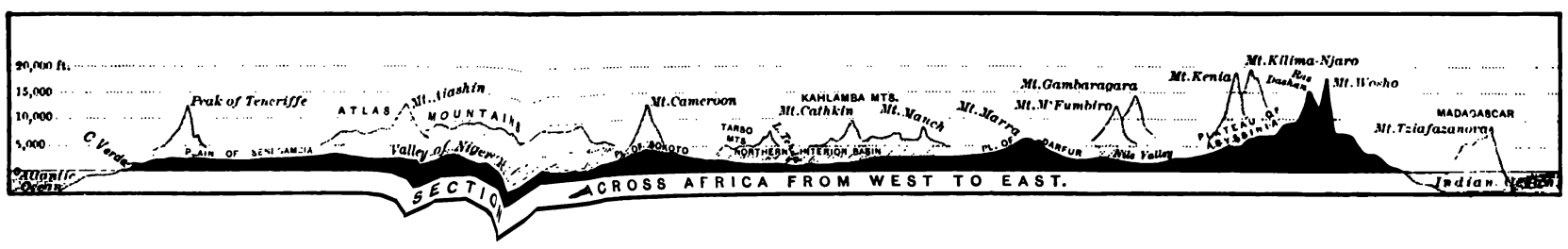
b. **The Soudan,** south of the Great Desert, a region of considerable fertility, containing a number of Mohammedan negro states.

c. The **Congo and Lake Region,** which is a low plateau abundantly watered, with extensive forests, a diversified surface, and inhabited by numerous tribes of pagan negroes of various degrees of barbarism.

d. A **Dry Plateau** near the Tropic of Capricorn. Lake Ngami occupies the lowest point. Part is a treeless desert, but much of it is scantily clothed with scattered trees or shrubs. It is inhabited in places by negro (Bantu) tribes.

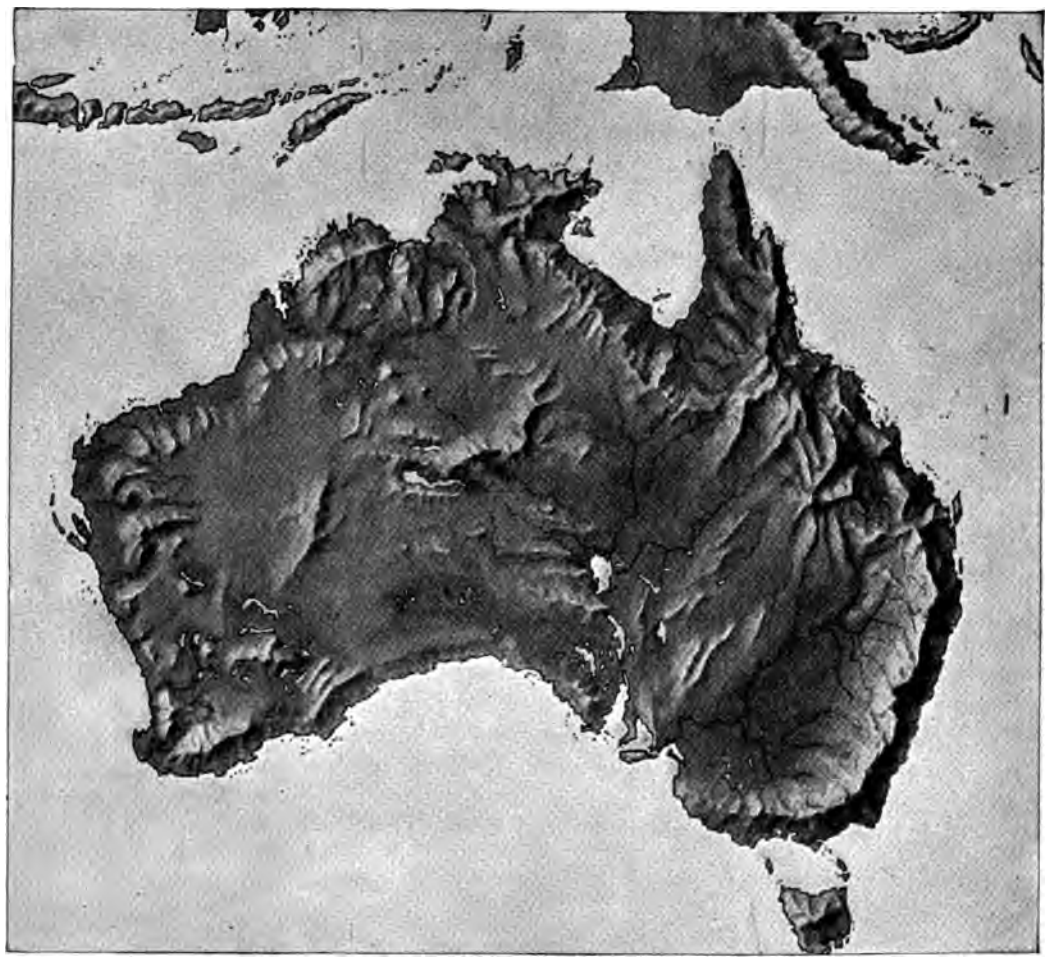
33. The **Low Plains** of Africa are confined to strips along the coasts separating the great plateau- and mountain-regions from the ocean. Those of the tropical portion, on both sides of the continent, are very unhealthful for the European races. Owing to the simplicity of structure, there are no deeply-indented bays nor outlying peninsulas. A belt of lowlands extends between the Atlas Mountains and the Sahara.

Questions.—What is the general character of the continent? In what directions do the mountain-ranges trend? What part of the plateau is lowest? Which mountains may be considered the predominant system? Describe the Eastern Highlands. What mountains bound the southern part of the plateau? What mountains on the western border? What mountains in the north? Describe the Great Desert of Sahara. What region lies south of this desert? What other regions belong to the interior? Where are the low plains?



IX. Australia.

34. **Australia** is the smallest of the six large land-masses which are now classified by most geographers as continents. The arrangement of its relief-forms resembles that of Africa. The greater part of it is a low plateau, with a general altitude of from 500 to 600 feet. Near the coast, mountain-chains rise upon the margin of the plateau around the whole continent. The Australian Alps and the Blue Mountains in the east and southeast are the only high chains, and may be considered the **Predominant System.** Mt. Townsend (7351 feet), Mt. Clark (7256 feet), and Mt. Kosciusko (7176 feet) are the highest peaks. The western coast-chains are much lower, the greatest elevation not exceeding 4000 feet, and there are some low ranges in the interior.



Relief Map of Australia.

Like Africa, Australia has few bays and peninsulas, and, except in the north, its coast-line is comparatively unbroken.

The interior plateau slopes gently down to the south and the low plain on the Australian Bight. Except at the base of the mountains, the greater part of the plateau is a dry stony desert.

The plain drained by the Murray River and its tributary, the Darling, and the eastern coast-plains are the most thickly-settled and the best-known portions of Australia. The western part and the interior have never been thoroughly explored, and the knowledge of the details of structure is vague. Several depressions are known to exist in the plateau which contain lakes that vary in extent with the season.

The land about the South Pole is called the **Antarctic Continent.** Only a part of its coast has been visited; so that we do not know either its outline or its area. There are mountains near the coast, south of New Zealand, two of which are the volcanic peaks—Mount Erebus (over 12,000 feet) and Mount Terror (nearly 14,000 feet). It probably snows nearly every day in the year. The interior is, apparently, entirely covered with ice, which descends in great glaciers to the sea. The waves dash against cliffs of ice which break up, and so fill the sea with icebergs that the coast can be reached only at favorable points.

Questions.—What continent does Australia most resemble in the arrangement of its relief-forms? Where are the mountains situated? Which ranges may be considered the predominant system? In what part of the continent then does the greatest elevation exist? What is the character of the interior plateau? In which direction does it slope? What portions of Australia are the most fertile and the most thickly settled? Where are the lakes found? What name is given to the land about the South Pole? What is the character of the coast? What is the probable climate? What two volcanic peaks have been observed?

X. Islands.

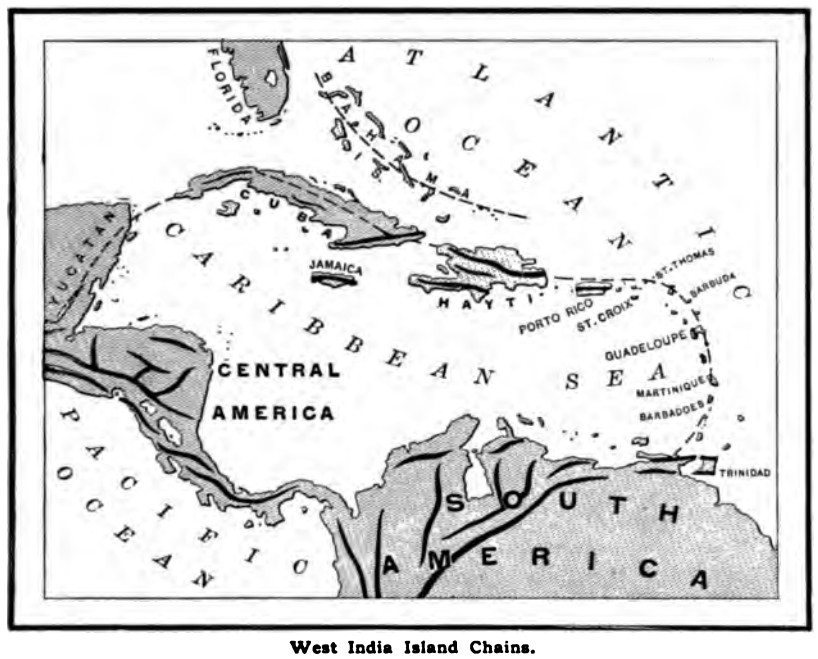
35. There are innumerable islands scattered throughout the oceans, but they form only a small portion of the land of the earth—probably not more than from one-twentieth to one-seventeenth. They are of two classes—**Continental** and **Oceanic.**

6. **Continental Islands** are situated near the continents, and, geologically considered, are a part of their mass. They are of similar structure, and have the same rocks, soils, and productions. They may be regarded as continuations of continental features, and often they are very obviously the summits of partially-submerged mountain-chains that belong to the systems of continental relief.

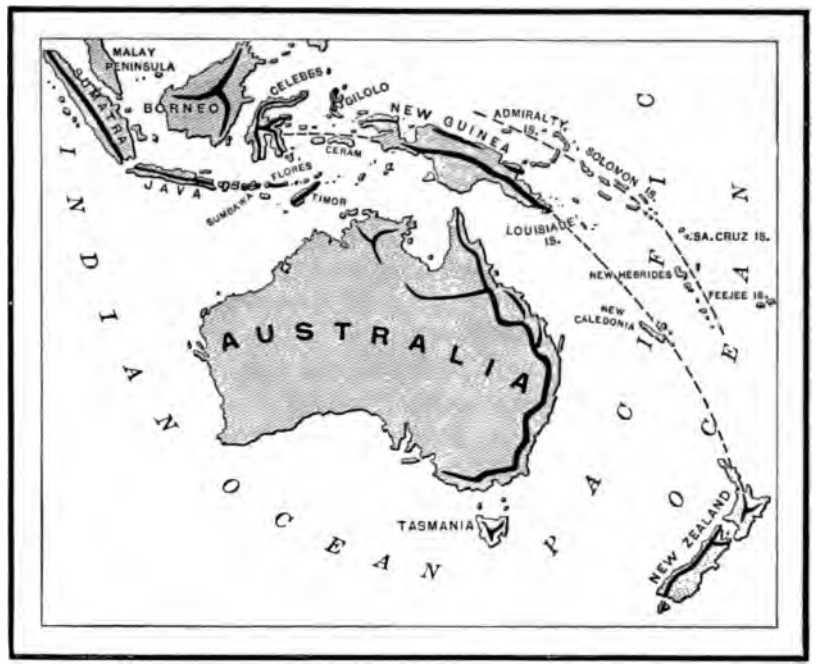
As has already been shown, an imaginary great circle may be constructed on the surface of the globe which will include, in one of the hemispheres thus formed, by far the greater part of the land-area of the earth. By examining a globe, or any of the large maps of the world, it will be seen that this mass of land belongs principally to the Northern Hemisphere, with projections extending into the Southern Hemisphere. A glance at the map on pages 30 and 31 will also make it apparent that those islands which correspond in geological formation and in character and productions to the adjacent mainland are either surrounded by shallow water, or are separated from the continent by seas or passages which have but a limited depth when compared with that of the oceans. For example, all the water of the Arctic Ocean is comparatively shallow; the Gulf of Mexico and the Caribbean Sea contain no great depths where their waters approach the mainland or the islands; the British Isles are surrounded by water which for miles from the coast does not exceed a depth of 600 feet. A stretch of shallow water follows the eastern coast of Asia from northeast to southwest between the mainland and the islands, and then sweeping to the east bathes the shores of the Sunda and Philippine islands and surrounds Australia and New Zealand.

There is ample evidence that the elevated portions of the earth's crust are grouped, somewhat rudely, around the North Pole, and that the different masses of land which constitute the continents are but parts of a great plateau, of which certain portions are submerged and of which the continents and the continental islands are the highest parts. There are depressions in the surface of this plateau: those which occur in the interior of any of the large elevated masses remain dry, though frequently containing bodies of salt water such as the Caspian and Dead seas; those which are near the borders of the plateau and communicate with the ocean are filled with its waters, and thus some of the elevated portions are separated from the greater mass and become islands.

The continents and the continental islands constitute a little more than ninety-nine one-hundredths of the whole land-area of the globe. The continental islands collectively contain a little more than six one-hundredths, and the remainder, less than one per cent., includes the Antarctic Continent and the oceanic islands.



West India Island Chains.



Australasian Chain.

The following are the most important groups and chains of the continental islands:

American Chains.—*a.* The Arctic Archipelago, comprising large islands which are detached portions of the Arctic table-land.

b. Newfoundland and the islands about the Gulf of St. Lawrence.

c. The West India Islands, which are principally the summits of a submarine mountain-chain which sweeps in a curve from Yucatan to the eastern termination of the Venezuela coast-range.

d. The Bahama Islands, belonging clearly by situation and structure to the low plains of the Floridian Peninsula.

e. The Patagonian Islands, on the west coast of South America, which are the summits of a submarine continuation of the Chilian coast-chain.

f. The islands west of British America and Southern Alaska.

g. The Aleutian Islands, which may be regarded as the continuation of the North American coast-mountains. They bound Bering Sea on the south.

Asiatic Chains.—The eastern side of this continent is accompanied by a series of curved island-chains, the summits of submarine mountains clearly belonging to the system of the Asiatic elevations. They extend from northeast to southwest.

Asiatic Chains.

a. The Kurile Islands, a continuation of the mountains which extend from north to south through Kamchatka.

b. The Japanese Islands, curving from Saghalin off the coast of Siberia to the Peninsula of Corea.

c. The Liu Kiu Islands, forming a curve from Corea to Formosa.

d. The Philippine Islands, forming two chains diverging toward the south. The eastern range terminates with the elevations of Celebes; the western, with those of Borneo. Celebes and Borneo, it should be remembered, belong to the group of the larger Molucca Islands.

In the annexed figures the trend, or direction, of these chains is indicated by dotted lines.

The **Australasian Chain** sweeps in a double curve from the Sunda Islands to New Zealand, and consists of a number of parallel island-ranges.

a. The Sunda Islands, curving from northwest to east, and including Sumatra, Java, Sumbawa, Flores, etc.

b. Ceram, New Guinea, and the Louisiade Archipelago, trending nearly northwest and southeast. In their continuation lie New Caledonia and the Loyalty Islands.

c. The Admiralty, Solomon, Santa Cruz, and New Hebrides islands, having the same trend as the preceding chain, and accompanying it on the northeast.

d. New Zealand, the southeastern terminus of the Australasian chain. Its northern end points toward New Caledonia, but the greater part curves southwest and is parallel to the coast of the Australian continent.

Tasmania is a direct continuation of the principal chain of the Australian mountains.

Other continental islands are Great Britain and Ireland, in Europe; Madagascar, east of Africa; Ceylon, south of India; and many others of lesser note.

37. **Oceanic Islands** lie in the wide expanse of the ocean—sometimes isolated, but more often in groups or chains. They may be regarded as the summits of submarine mountains rising from the profound depths to the surface of the sea.

Sailors divide them into two classes—the *high* and the *low*, which represent two kinds of material and two modes of formation. The high islands are volcanic; the low, coral.

38. **Volcanic Islands** are usually in lines or elongated groups, though some are entirely isolated. They are of various sizes and aspects, from the mere reef, over which the waves dash, to large islands with towering peaks. (A reef is a rock rising so near the surface that the waves break on it, but not so high as to prevent them from dashing over it.) Some of the chief oceanic islands are:

a. **In the Atlantic.**—Iceland, the Azores, Canaries (Teneriffe, 12,182 feet), Cape Verde, St. Helena.

b. **In the Pacific.**—The Hawaiian Islands (14,000 feet), the Society Islands (Tahiti, 7000 feet), Marquesas, Juan Fernandez, Easter Island, Pitcairn, and various others.

c. **In the Indian Ocean.**—Socotra, the Seychelles, Mauritius, Réunion, Kerguelen, and others of lesser importance.

39. **Coral Islands** are composed of coral, a kind of limestone formed by the growth of small marine animals belonging to classes called *Hydrozoa* and *Anthrozoa*.

There are many species of coral-animals, which have a skeleton of carbonate of lime produced from sea-water. Some are very rare, some are of great beauty, and others grow in such vast numbers that their dead calcareous skeletons form the limestone which constitutes coral islands and coral reefs.

The "reef-building corals" cannot live in either cold or muddy water. They are found only where the water maintains a temperature of at least 68° Fahr., and they flourish best on the outside of reefs, where the water is clearer, and where the currents and waves bring a plentiful supply of food. They do not grow in water more than 20 fathoms deep, and they die when exposed to the air; so they build only in shallow water between 120 feet and low-water mark.

An Atoll.

Coral-formations are of three kinds, *Fringing Reefs*, *Barrier Reefs*, and *Atolls*.

Fringing Reefs are mere belts of coral attached to the shore, usually extending into the water but a few hundred yards, rarely much more, and sloping abruptly when they reach deep water.

These reefs occur in countless localities, impinging on the land in water which is suitable for their growth.

Barrier Reefs lie off from the shore, and are separated from it by a channel of navigable water.

The grandest example of this kind is the Great Australian Barrier Reef, which extends parallel to the eastern coast of Australia for 1200 miles, with a channel between it and the mainland which varies from a few hundred yards to 20, or even 50, miles in width.

The outer slope of a barrier reef usually descends with great steepness to a depth of several thousand feet; the inner slope is much more gentle, and the waters inside are more shallow; and in all extensive reefs there are numerous passages through the reef from the outer ocean to the calmer waters inside.

Barrier reefs may extend entirely around an island, encircling it like a broken ring. In such "*encircling reefs*" there are almost always passages through the ring of coral to the inner channel.

Atolls are the most remarkable and the most striking of the coral-formations. They assume a variety of aspects. Sometimes the atoll is a small island in the shape of a ring, a narrow circular strip of coral with a reef outside and a lake or lagoon inside which is connected with the sea by an opening. More often the atoll consists of many islands and knots of coral standing in a ring-shaped reef with a deep lagoon in the middle, and with numerous openings through the ring between the central lagoon and the outer ocean.

Atolls are sometimes nearly circular, but are more frequently irregular in shape, and are of all sizes from a mile to 20 miles or more across, and they may occur singly or in groups. The number of separate islands, inhabited and uninhabited, must be reckoned by tens of thousands.

Dangerous Archipelago, east of the Society Islands, is an assembly of eighty atolls, mostly circular, against which the surf beats with such violence that the sound may be heard for miles.

The Caroline Archipelago, north of New Guinea, comprises sixty groups of atolls extending a thousand miles in length.

The word "*atoll*" was taken from the language of the inhabitants of the Maldive Islands, in the Indian Ocean. These islands consist of thirteen atolls, each with its separate name, and some thousands of islets, many of which are mapped and have been named. The sultan calls himself "King of the thirteen Atolls and twelve thousand Islands."

The origin of atolls has been the subject of much study and discussion. There are two theories to account for their wonderful shape and structure. The oldest theory is that of Darwin, which assumes that they occur chiefly in those parts of the ocean where the bottom is sinking while the coral constituting the atoll continues to grow toward the surface; that the growth began as fringing reefs around islands; that as the bottom of the ocean and the island slowly sank the coral continued to grow upward and kept to the surface; that then, as the process went on, the growth being most vigorous at the outside, this fringing reef became a barrier reef. This process is supposed to have continued and the floor of the ocean to have sunk until the original peak disappeared below the surface of the sea, leaving a lagoon in its place. We find islands in all stages of such a process.

The theory of Murray assumes that a sinking of the floor of the ocean is not a necessary condition. Sediment is always falling to the bottom. In tropical seas this is largely composed of shells and other remains of animals which thrive near the surface, and the deposit increases faster as the water becomes more shallow. Thus the tops of submarine mountains increase in height faster than the deeper bottom does. When these tops rise into shallow water which is warm enough for corals to flourish in, they will soon reach the surface. The fact that corals grow faster on the outer portions of the reef gives rise to the atoll form, and the inner lagoon is further developed by the slow solution of the dead coral by the sea-water. It is now believed that atolls may be formed either way, Darwin's theory best explaining the origin of some, Murray's theory that of others.

The soil of coral islands consists of coral-sand. The natural productions are few, and although the islands are often of great beauty, and though many of them are densely populated, they are at best but poor abodes for civilized and enlightened people. (*Consult Dana's "Corals and Coral-Islands."*)

Questions.—What portion of the land consists of islands? What are the two classes of islands? What are continental islands? Describe their relation to the mainland. Name some of the important American continental islands. Some of the Asiatic chains. Australasian chains. Where are the oceanic islands found? Into what classes are they divided? Name some of the chief volcanic islands. What are coral islands? What is their origin? What conditions are necessary to the existence of coral-animals? How many kinds of coral-formation are there? What are fringing reefs? Barrier reefs? Atolls? What theories account for the formation of atolls? Are coral islands generally well suited for habitation?

REVIEW AND MAP QUESTIONS.

Which are the more continuous, the bodies of water or the bodies of land? Has all the land been explored or surveyed? About what proportion of the earth's surface is occupied by the land?

What is generally meant by the term continent? What two large divisions really constitute but one mass of land, and are, therefore, sometimes considered as one continent? Is Australia now considered as an island or as a continent? What name is given to the land around the South Pole? On which side of the equator is the greater part of the land? What proportion of the land is included in the "land hemisphere"?

Toward which pole is the greatest breadth of the large land-masses? Toward which pole do most of the peninsulas extend? What is the approximate geometrical shape of the continents?

Which continent has relatively the most extended coast-line? Name in order the other continents with reference to the length of coast. What effect has this physical characteristic produced in the development of civilization?

In what two aspects is the shape of the land-areas considered? Which of these is more readily represented on maps? What is relief? Name the features of surface-area which constitute relief. What are mountains? How are they usually disposed? What is a peak? A crest? What are passes? What is a butte? What is a mountain-system?

Give an example of mountains produced by eruption. By folding. By fracture. By two or more of these causes. Which class of mountains is the most rugged? By what other agency is the character of relief modified? What are table-mountains? Mention an example of a longitudinal valley. Of a transverse valley.

How do plateaus differ from mountains? Is the difference between plateaus and plains always perceptible? What kind of climate and what kind of soil are usually characteristic of plateaus? What are parks? Name some of the varieties of low plains. How are alluvial plains formed? Which kind of land, high or low, is most densely populated?

How are the great forms of relief arranged in each of the continents? What general rule does the location of the predominant mountain-system follow? How do continents and islands differ? Is the general arrangement of the component parts exactly the same in all the continents? Which is the largest of the continental land-masses? Which is second in area? Name the other continents in the order of size. What is known of the Antarctic Continent?

What are continental islands? Are they usually separated from the mainland by deep or by shallow water? How do they resemble the adjacent continents? Describe the great plateau of which the continents and the continental islands are parts. What proportion of the land-surface of the earth is occupied by this plateau? What part of the whole surface do the continental islands constitute?

What are oceanic islands? Into what classes are they divided by sailors? What two modes of formation do these classes represent? What is meant by a reef? Name some of the important oceanic islands in the Atlantic Ocean. In the Pacific Ocean. In the Indian Ocean.

Of what are coral islands composed? In what kind of water do the reef-building corals exist? What are the varieties of coral reefs? Which is the best example of a barrier reef? Which side of a barrier reef has usually the steeper slope?

Describe an atoll. In what part of the globe are atolls most numerous? What is the character of the soil of atolls? Are they well suited for habitation by civilized people? What theory of the origin of atolls was formulated by Darwin? How does this differ from Murray's theory? Which theory is more generally accepted?

(*In answering the following questions consult the map, pages 30 and 31, and the various relief maps.*) What is the predominant mountain system of North America? What plateau toward its southern end? What great plateau north of this? In what parts of this system are volcanic peaks found?

Where does this system attain its greatest width? What name is given to the eastern chains? The western chains? Where is the Great Basin?

Upon which side of the continent is the secondary system? What is its extent? How does its height compare with that of the main system?

What is the general direction of both mountain-systems? What is the character of the land between them? Where is the "Height of Land"? What plateau in the eastern part of the continent? Where are the most extensive sections of lowland? What sections are below the sea-level?

Near what ocean is the predominant mountain-system of South America? Of what system is this a continuation? What great plateau is included between its ranges? What great rivers rise in the northern part of this system?

Name the secondary mountain-systems of South America. Where are they situated? Where are the low plains? By what names are they known?

How do the relief-forms of Europe compare with those of North America and South America? What are the direction and extent of the predominant mountain-system? What plateau is part of the main system? Name the principal chains and plateaus to the south. What plateaus are north of the Alps?

What chain forms part of the boundary between Europe and Asia? What is the general character of the northern part of the continent? Name some of the small plains in the mountainous region.

How does the general arrangement of the relief of Asia compare with that of Europe? Where is the highest part of the continent? Does any other portion of the globe equal this in altitude?

From what center do the ranges radiate? What great range is south of the Plateau of Thibet? Where is the Great Central Plain or Mongolian Plateau? By what ranges is it surrounded? What desert within its limits? Where are the Hindoo-Koosh Mountains?

Describe the Plateau of Iran. The Plateau of Asia Minor. What is the character of the Arabian Peninsula? Where is the Plateau of the Deccan?

What great low plain in the north? What section is below the level of the sea? What plains along the eastern coast? What plain south of the Himalayas? North-west of the Persian Gulf?

How may the relief of Africa be described? What part of the plateau is lowest? Where is the predominant system of mountains? What mountains in the south? On the western coast? What groups in the north?

What great desert in the northern part of the continent? Which part of this desert is lowest? Highest? Where is the Soudan? The lake-region? Where are the dry interior basins? Are the low plains in the interior or along the coast?

What continent resembles Africa in its physical arrangement? Which is the lowest part of the interior plateau of Australia? Where is the principal mountain-system? In what plain are the most extensive settlements?

Name the most important continental islands associated with North America. Of what mountains are the Aleutian Islands a continuation? What islands are an extension of the mountains of Chili?

What groups of continental islands skirt the eastern shore of Asia? What group of large islands south-east of the China Sea? What groups of islands form a continuation of the mountains of the Malay Peninsula? What island forms a continuation of the main mountain-system of Australia?

What continental island south of Hindoostan? East of Africa? What group of continental islands off the western coast of Europe?

THE WATER.

I. Properties of Water.—Springs.

1. **Water** covers nearly three-fourths of the earth's surface, or an area of from 144,000,000 to 147,000,000 square miles.

It exists in nature in three states. As ice and snow it is solid; in its most familiar form it is liquid; and it occurs in the atmosphere as a gas or vapor.

Absolutely pure water is clear, colorless, and without taste or smell. But it has wonderful solvent powers, and dissolves such a variety of substances with which it comes in contact that it is never found chemically pure in nature.

Fresh water freezes at 32° Fahr., boils at 212°, and evaporates at all temperatures; but salt water freezes at a lower temperature, boils at a higher, and evaporates more slowly.

By far the greater part of the water of the globe is collected in the sea. It evaporates from both the sea and the land into the atmosphere; it falls in rain; it flows in rivers and streams and reposes in lakes; it is also found in all soils; it is a constituent part of some rocks and minerals, and of all vegetable and animal bodies. It is therefore wellnigh universally distributed over the earth.

2. **Springs** are streams of water that issue from the ground. Water falls upon the land as rain or snow: a portion flows off the surface into the streams and lakes, a portion sinks into the soil, and a portion evaporates into the atmosphere. That which sinks into the soil completely saturates it and fills all the cavities and crevices in the rocks below a certain depth. This is called **Ground-Water.** This ground-water is ever seeking lower levels by percolation. It sinks into the soil in the higher lands, and issues as spring-water where the land is lower.

Springs are produced in several ways, according to the character of the surface, the soil, and the underlying rocks. Sometimes the water accumulates in porous strata, which lie between or beneath others less porous, and flows out where the porous strata reach the surface on the hillsides. Sometimes the water finds its way along fissures or other passages in the rocks, and issues where these channels reach the surface. If it flows from the ground in a stream, it constitutes a spring; if over a considerable area, it may produce a swamp. For several reasons, springs are most abundant in hilly and mountainous regions, and swamps in more level places. All swamps, however, are not produced by springs.

3. The quantity of water discharged by springs varies from a very small amount to enough to form a river. Great springs of the latter class occur usually in hilly or mountainous regions beneath which there is a stratum of limestone or volcanic rock.

The celebrated spring of St. Winifred, at Holywell, the most copious spring in England, discharges 4400 gallons per minute, and the water in its short course of little more than a mile to the sea turns eleven mills. The springs of Carlsbad, Germany, give nearly 200,000 cubic feet of water daily. The San Marcos River, in Texas, emerges full-grown from a gravel-bed beneath limestone, and Fall River, in California, emerges from beneath lava. In many cases the water flowing from a single spring is sufficient to form a mill-stream.

4. **The Flow** of most springs is variable. A few vary very little with the season of the year, but change from year to year, according to the average rainfall. Others vary with the season, the most copious flow occurring in the spring and early summer, or, as in the tropics, the flow increases after the rainy season and diminishes with the later dry season. Still others flow only when the soil is wet, and cease entirely in times of drought.

Still others are **Intermittent,** but these are very rare. Perhaps the most noted is that at Paderborn, in Prussia, which formerly flowed for six hours, and then ceased entirely for six hours. Such springs are supposed to be due to a natural siphon-shaped fissure in the rocks, emptying underground cavities, which fill slowly, to be again emptied as soon as the water reaches the top of the siphon.

5. **The Temperature** of springs also varies greatly—from that of icy coldness to that of boiling water. The temperature is usually about that of the average or mean temperature of the place. Deep-seated springs are usually warmer, and hot springs and geysers have their waters heated by the internal heat of the earth or by volcanic rocks not yet cooled.

6. **Mineral Springs.**—Water is never absolutely pure in nature. It has great solvent powers, and absorbs gases from the air and minerals from the soil and rocks. When the amount of dissolved matter is too small to be perceived by the taste, we call it *fresh water;* but most of the water of the earth is *salt water* or *mineral water.*

There is usually a mixture of the mineral ingredients dissolved, the water taking its name from the most obvious or most important ingredient. *Alkaline water* contains carbonate of soda; *bitter water* contains the sulphates of magnesia and soda; *sulphur water* is impregnated with sulphuretted hydrogen in quantities sufficient to be perceived by the sense of smell; *chalybeate waters* contain iron in solution; *salt waters* and *brines* contain common salt. Salt springs occur in nearly every country, and most of the salt used by the civilized world is produced from salt springs or salt wells. In the Western United States many springs which effervesce with carbonic acid or other gases are called "*soda springs,*" although they may contain no soda.

7. **Wells** of all kinds are artificial sources of water, while springs are natural sources. By far the most common kind of well is simply a hole dug deep enough to reach the ground-water, and usually protected by stone to prevent it from caving in.

Artesian Well.

The use of such wells has been the common method of obtaining water from remote times and in all countries. *Driven wells* are simply iron pipes driven into the soil until water is reached in a porous stratum, from which it is pumped.

8. **Artesian Wells** are bored rather than dug, and are usually deep; the principle of their action is readily understood from the accompanying diagram. The water, falling on high ground, sinks into sloping porous strata and flows beneath more impervious beds. When these are pierced at some lower level, the water rises to the surface through the boring.

The famous well at Grenelle, near Paris, is 1798 feet deep. The water rises 32 feet above the surface, and the flow is over 500 gallons per minute. There is a well at Mascoutah, Illinois, 3100 feet deep; one at Pesth, in Austria-Hungary, which is 3120 feet deep; and there are others which are still deeper.

Some artesian wells yield immense quantities of water, and they are extensively used for irrigation. Oases in deserts have been fertilized by them, and in some cases they have been bored beneath the salt water of shallow harbors. Some artesian wells yield salt water. The *oil-wells* of Pennsylvania and other States are artesian wells in construction, yielding petroleum.

Questions.—What proportion of the earth's surface is covered with water? In what three states does it exist? How is it distributed? What are springs? How are they produced? What is a swamp? Where do the largest springs usually occur? How does the flow of springs vary? What is the usual temperature of a spring? What is a mineral spring? What is a well? An artesian well? What are oil-wells?

II. Rivers.

9. The water which accumulates beyond the evaporation and the absorption by the earth issues from the ground and at once seeks the lowest attainable level, thus forming streams. The place at which a stream has its origin is called its **Source.** The point at which it empties its waters into another body of water is called its **Mouth.**

While the source of a stream is usually a spring, it may be a swamp or a lake, or the water-supply may be furnished by the melting of snow or ice on the summits or sides of mountains.

10. **Rivers** are streams of water which flow in a channel on land. The water which issues from the ground as a spring forms at first a small rill or brook. By the confluence of many brooks rivers are formed, which in their onward course receive tributaries and increase in volume.

A great river is made up of many tributaries. The Rhine is said to have over twelve thousand, and such great rivers as the Amazon and Mississippi have many times that number.

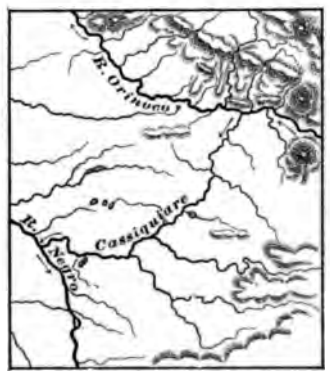
A river, with all its tributaries, is called a **River-System,** and the entire extent of land drained by a river-system is called its **Basin, Drainage-Area,** or **Watershed.**

The term *basin* is commonly used in ordinary description, and *watershed* is more used by engineers. Both terms are somewhat misleading. The term "basin" implies a depression with a visibly elevated margin, which is not the case with many such drainage-areas. The term "watershed" (from the German *Wasserscheide*, a "water-parting") is used by some geographers to designate the "divide" rather than the area drained.

Various names are given to streams. A small brook is often called a *rivulet*, and a larger brook a *creek* or *run*.

11. **Divide.**—The line or ridge of elevated land which separates one river-basin from another is called a divide, but it does not follow that it is always marked by mountain-ranges or hills. The divides of some of the largest rivers pass through low plains; as, for example, that which separates the Mississippi Valley from the basin of the great lakes, which is in many places a level plain but a few feet above the water of the lakes.

The actual divide may be so flat that the upper waters of the two river-systems may actually connect, the same river dividing and sending its branches to different river-basins. Such division of a river is called **Bifurcation.** The best-known example is the Cassiquiare River, in Venezuela, which connects through its bifurcation the river-systems of the Amazon and the Orinoco.



Bifurcation of the Cassiquiare.

Two-Ocean Creek, in the Rocky Mountains, in Northwestern Wyoming, which connects the river-systems of the Mississippi and the Columbia, is even more striking.

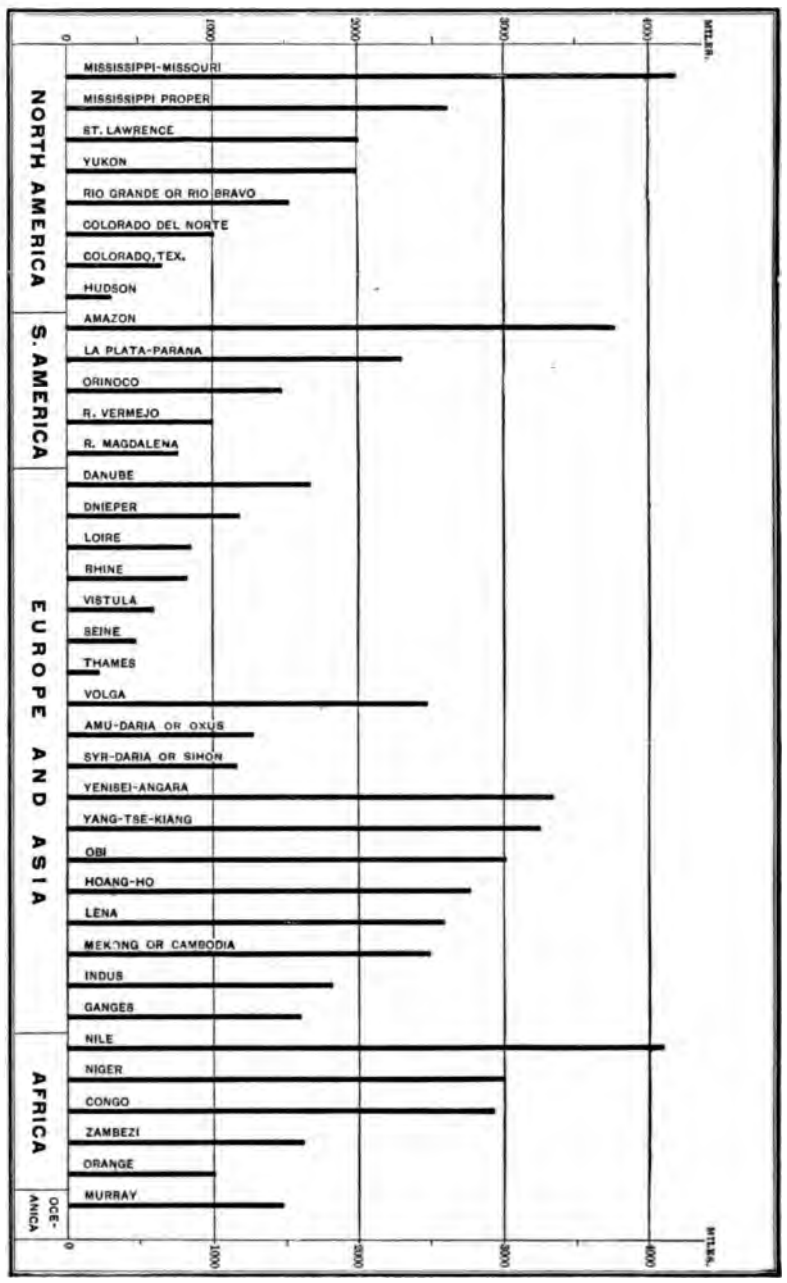
There are numerous cases where upland swamps have two outlets which run into the head-waters of different river-systems.

12. The **Amount of Water** in rivers depends on (*a*) the extent of the territory they drain; (*b*) the amount of rain and snow falling in the region; (*c*) the physical features of the country through which they flow,—a well-wooded country impeding, an open one favoring, evaporation; and (*d*) the climate,—heat and dry atmosphere increasing the loss of water by evaporation.

The amount of water discharged by different rivers is not always proportionate to the length of the river, or to the relative size of the area drained by the river-system. In some cases it is dependent upon both the size of the basin and the amount of rainfall; in others the great extent of the drainage area compensates for a fall of rain below the usual average, and in still others extraordinarily heavy rainfalls may supply a vast amount of water in a comparatively small basin.

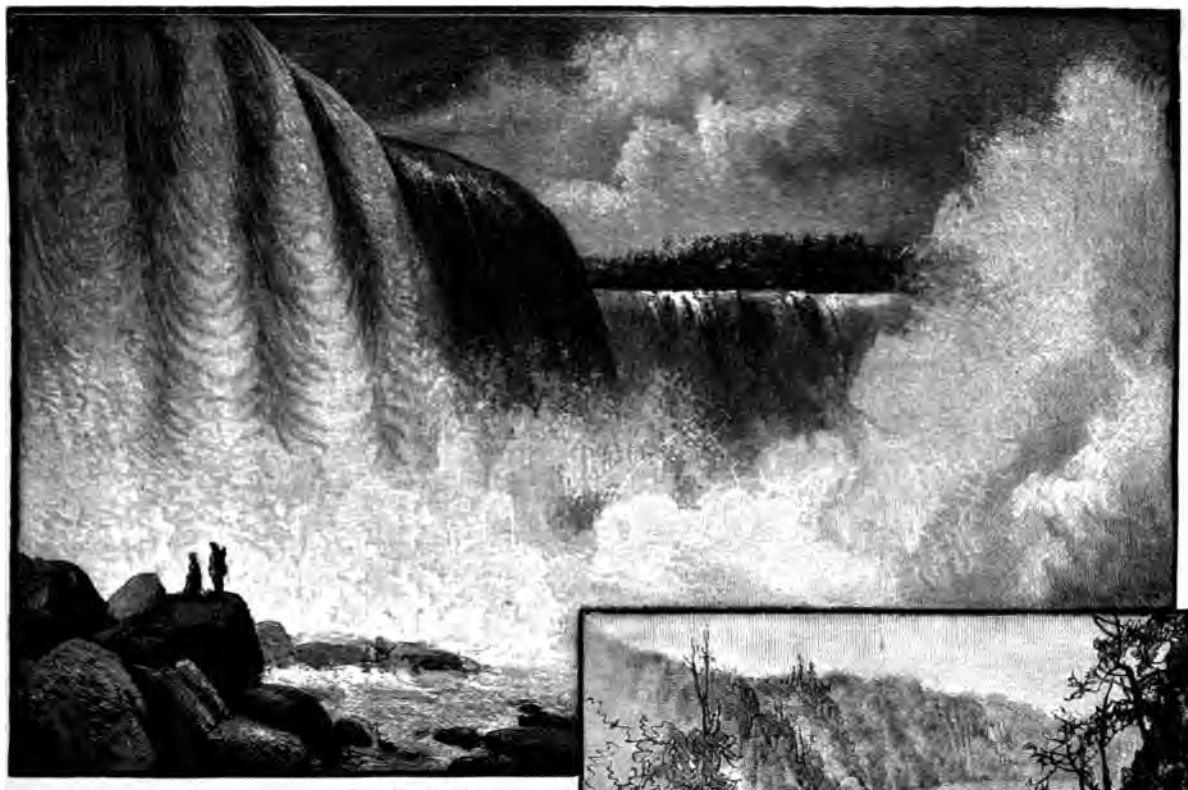
The Mississippi River discharges annually nineteen and a half trillions of cubic feet of water into the sea—about one-fourth of the amount furnished to its territory by rains; the Missouri, about three and three-quarter trillions; the Ganges, five and a half trillions; and the Indus, about seven and four-fifths trillions (7,884,000,000,000).

13. The length of a river is dependent upon the nature of the country through which it flows. Mountain-streams which traverse narrow coast-plains are necessarily short, while rivers draining extensive interior plains are of great length. The subjoined table gives the relative lengths of the more important rivers of the world.



The Relative Lengths of some of the more Important Rivers.

On account of the arrangement of the predominant mountain-systems of the different continents, most of the great plains of the earth slope toward the Atlantic Ocean or one of its great inland arms, and, as a consequence, it receives either directly or indirectly the drainage of these areas. As the Arctic Ocean is in reality but an arm of the Atlantic, the rivers of the Arctic slopes may be classed with those of the Atlantic System. The region thus drained constitutes about one-half of the whole land-surface of the globe, and contains many of the longest rivers.



Niagara Falls.

14. The **Velocity** of rivers depends on their descent or fall and the depth of water. A velocity of from 2 feet to 4 feet in the second is moderate; from 4 feet to 10 feet is great. The Rhine at Basle flows 7.5 feet in a second when highest, but only 3.4 feet when lowest.

The descent per mile of the Mississippi is, from the city of Memphis to the mouth, 4.8 inches for the low-water slope, but 5.2 inches for the high-water slope.

The velocity of any river is not the same at all points in its course. The slope or descent of the river-bed affects the speed of the water. The steepness of its slope is almost always greatest near the source of the river and decreases toward the mouth, so that the velocity diminishes with the onward flow of the stream. The slope, however, is seldom uniform, but is composed of a series of grades. In places where the inclines are the greatest the speed is most accelerated, and where the course lies through alluvial plains the flow is apt to be sluggish. Very decided inclines produce rapids or falls. As the stream increases in size the width of the valley produces changes in its velocity. Where the same volume of water is forced through a narrow channel, it naturally moves more rapidly than where it can spread out over a greater surface. There is also a very noticeable variation in the rapidity of the current due to the amount of water carried at different seasons; under similar conditions, the velocity is greater at high water than at low.

Friction also governs the rate at which a stream progresses. The water at the sides and at the bottom is retarded by coming in contact with the solid earth, and the surface-water in the deepest and most central portions flows with the greatest rapidity. In broad, shallow sections of a river the friction is relatively greater, and the progress is consequently slow.

15. **High Water and Overflow.**—Most rivers have a season of *high water*, when they are subject to *overflows* caused by rain and melting snow. Some rivers in tropical countries where there are but two seasons, a rainy and a dry season, overflow their banks annually.

The annual overflow of the Nile was a mystery until lately. This great river is the outlet of several large lakes, and its course lies chiefly in a rainless district: hence its flow would be quite regular if it were not for its tributaries, the Blue Nile and Atbara, which have their sources in the elevated plateau of Abyssinia, and are swollen enormously during the rainy season of that country. This rise reaches lower Egypt in June, when the low country is inundated. The flood is at its height in August and September. By November the water has fallen, grain is sown in the wet muddy soil, and abundant harvests follow.

The overflow of the Ganges is as regular, but less striking. It begins in May, and is at its height in July, when large tracts are flooded.

Most of the rivers of the middle latitudes, like the Mississippi, have a regular period of high water, and many are subject to occasional overflows, caused by unusual storms.

Rivers that are the outlets of great lakes, like the St. Lawrence, San Juan, etc., are more regular in their height.

Trenton Falls.

16. **Falls and Rapids.**—Falls or cataracts are formed only in rivers with rocky beds. If the stream runs over a precipice which is perpendicular, or nearly so, it forms a *fall;* if the stream is very small, the fall is called a **Cascade;** if the river-bed is rocky and the descent steep, rapids occur. In a fall the water pours over a precipice; in rapids it tumbles over and passes between rocks.

Cataracts occur in rivers flowing over horizontal strata. Some hard stratum or series of strata, which form the bed of the river, resists the erosive action of the water more than the underlying layers, and, as these wear away, the harder rock remains overhanging until the force of gravitation and the pressure of the descending waters cause it to break off and fall. Rapids are usually found in streams which flow over oblique strata. As the harder layers of rock wear more slowly, portions of them remain after the softer material is removed, only to be more gradually worn away by the tossing current.

The condition of the water carried by the stream also has its influence in producing falls or rapids. If the water is very muddy or is charged with sand or gravel, its corrasive powers are increased, and the hard rock is more easily worn away. It is a noticeable fact that large cataracts occur in rivers which have clear water, while they are seldom if ever found in muddy streams.

The grandest cataract on the globe is the Niagara Falls, between Lakes Erie and Ontario. The waters of the Niagara River, about three-fourths of a mile in width, plunge here over a precipice 160 feet high. The Victoria Falls of the Zambezi River were discovered by Livingstone, the African explorer, and in volume of water rank next to those of Niagara. They are 360 feet high.

The highest fall thus far known is that of the Yosemite, in California. A small creek, a tributary of the Merced River, plunges over a rocky precipice of the Sierra Nevada over 2000 feet high. Two projecting ledges break the fall into three sheets of water.

The Trenton Falls, in New York, formed by a tributary of the Mohawk River, descend, in four cascades, 180 feet.

17. **Erosion.**—The wearing away of the bottoms and banks of rivers by running water is called *erosion*. How this takes place has already been described on page 17. It is most noticeable in the bed of the river and its immediate vicinity; and, as in the case of a great cataract like Niagara, the process is carried on almost entirely by the current of the river, but in most cases it in reality affects the whole area drained by the river-system. In the most remote parts of the basin, the rain, the frost, and chemical action are continually disintegrating particles of rock and soil, which are carried to the main river or to one of its tributaries. In the channel and bed of each stream erosion is at work with greater force. Near the source, where the descent is the greatest, the velocity of the current, especially in times of flood, enables it to tear away the rocks which form its confines, and to use the detached fragments, whether large or small, in continuing the destructive work.

As has already been stated, many mineral substances are soluble in water, and the falling rain or the running brook absorbs a certain portion of such materials, which becomes invisible and for the time loses its identity and forms a constituent part of the water. Many of the sedimentary rocks consist of insoluble particles cemented together by mineral matter which yields to the solvent power of water, and thus these more refractory portions become detached. These and larger masses of rock are mechanically eroded, and moved by running water, while the substances held in solution are detached by chemical or physical forces, and remain absorbed by the water till precipitated by some other dissolved reagent or by some change of temperature or pressure.

The most remarkable instance of erosion is that of the Grand Cañon of the Colorado River, a deep chasm 300 miles in length, and from 3000 to 6000 feet below the surface of the plateau. The walls rise in a series of steps, or terraces, each one from 100 to 1000 feet high. In some portions of this region the cañons are so numerous that only pinnacles and flat-topped columns of the original plateau are left.

The tributaries of this great river have also cut their courses in similar cañons, making the whole region one of majestic grandeur. The cañon represented in the illustration is the result of ages of erosive action by the Rio Virgen, one of the Colorado's tributaries.

Pa-ru-nu-weap Cañon.

18. **Transportation and Deposition.**—The materials eroded in one place are carried along by the stream and left at a lower level. This is called *transportation*, and depends chiefly upon the velocity of the current. When the velocity is sufficiently diminished, the transported material settles to the bottom. This is called *deposition*.

All solid bodies have their weight more or less sustained in water. Light bodies float; ordinary rocks have one-third or one-half their weight sustained, so that they are much more easily moved in water than out of it. Very fine particles are suspended—that is, they mix with the water and render it turbid or muddy. If a mass of ordinary soil be thrown into fresh water, the stones and gravel sink rapidly, the sand more slowly, while the clay will remain more or less suspended, soiling the water. The coarser particles will sink quicker they sink.

Transportation by running water is regulated by a similar rule: the coarser the material, the greater the velocity required to move it. A mountain-torrent in times of freshet will tear from their beds and move along masses of rock weighing many tons, while a gentle current, no matter how large the river, will transport only very fine material, and in lakes without current the fine mud will settle, leaving the water clear.

In streams which are the outlets of lakes the water is usually clear, while in those which rise from springs and receive the immediate drainage of the surrounding country it is generally muddy, especially during freshets.

Along the upper and swiftest portion of a stream rocks and pebbles are deposited when the velocity becomes insufficient to move them farther. In a mountainous or hilly country the brooks and streams are filled with loose fragments of rock, and the bottom and sides are lined with pebbles of various sizes, worn more or less smooth by grinding one against another. Lower down the stream only small pebbles, gravel, sand, and coarse particles of mud are deposited, while the finer mud is carried to the mouth of the stream or beyond. In times of freshet a stream carries more solid matter and moves the larger fragments farther down its course, because the heavy rainfall or sudden melting of snow increases the turbidity of its waters, and also because its greater volume adds to the speed and transporting power.

The disintegration or erosion of matter is accomplished by a variety of means; the transportation and deposition are entirely the work of streams. Near the source the deposits are only temporary, and the channel is V-shaped. The relative amount of deposited matter increases as the river progresses through more level regions and the angle cut by the channel water is less acute. The river at all points, except in the delta, is, nevertheless, continually working its way lower and lower, leaving terraces at its sides to mark its former bed; with time, its valley increases in breadth, and all rivers tend to reduce the land to lower levels.

Finely-deposited material is called *silt*, and shallow places formed by deposition are called *bars*. The formation of bars in rivers and in fresh-water lakes is regulated strictly by the velocity of the current, but another law modifies the formation of bars in salt water at the mouths of muddy rivers. Salt curdles suspended mud and makes it settle more quickly. Muddy river-water like that of the Mississippi—which requires weeks, or even months, to settle if kept fresh—will become clear in a few hours when mixed with sea-water.

19. In most rivers it is possible to distinguish between three different sections of their course—the **Upper Course,** the **Middle Course,** and the **Lower Course.**

The upper course is that portion which flows in a mountainous or hilly country. It is characterized by a steep descent and great velocity. The valley is narrower here than at any other point. Sharp turns, angles, and straight lines of considerable length succeed each other in this part of the course. Falls and rapids are common; the erosion is mostly at the bottom, and rocks and gravel, as well as mud, are moved along the bed.

The middle course begins where the river emerges from the mountains. The descent has but a slight grade, and the river flows in a well-defined bed, with alluvial flats—or "river-bottom"—along the shores, subject to overflow by the higher freshets. The bed is formed

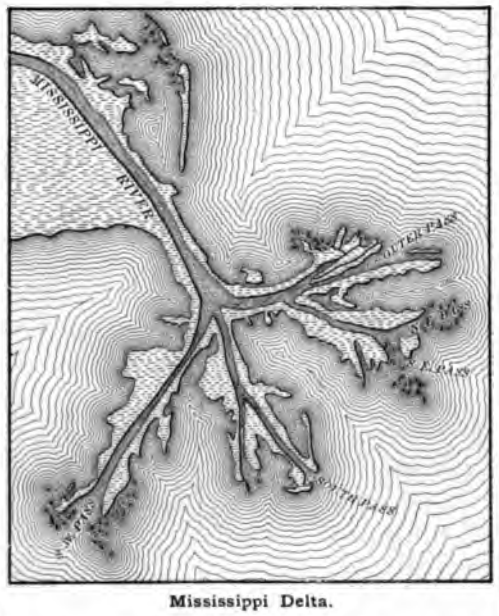
of more yielding materials, which are easily washed away by the flowing waters. The erosion is mostly at the sides and the eroded material is finer, and the decreased velocity renders the river more liable to be turned and to change its direction. These conditions produce rounded curves very different from the sharp, angular bends of the upper course. The necks of these curves are easily washed away, and thus islands nearly round, and bow-shaped lakes, are formed. When there is an unusually high flood, the water, if obstructed, sometimes forces its way through the soft alluvial banks, forming a new course, and thus abandoning its former and more circuitous route. The old curves are then left dry, or as their outlets are closed with silt they become lakes.

Sinuosities of the Mississippi.

The turnings and twistings of a river in its passage through the alluvial plains are called *sinuosities*, and are most apt to occur at points where the main stream receives its tributaries. The force of the new current deflects the water toward the opposite bank, and also tends to deposit the mud with which it is charged across the normal course of the greater river. The not infrequent result is the turning of the stream in the direction of the new current. The Mississippi River affords a good illustration of these sinuosities, as shown in the diagram.

The lower course begins where the surface of the river is scarcely higher than the ocean and the low alluvial banks rise but little above the water.

20. **Deltas.**—About the mouths of many turbid rivers there is a low, level, more or less swampy region formed by the silt, or earthy material brought down by the current. This alluvial tract is called a *delta* (from the Greek letter Δ, which is the shape of the Nile delta). In the delta the river divides into smaller channels and reaches the sea by several mouths.

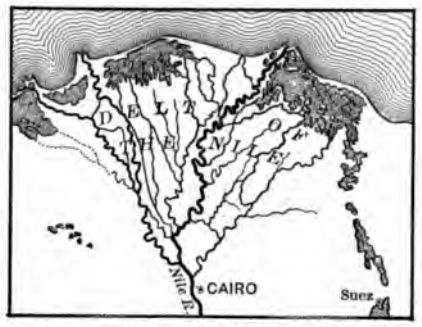


Mississippi Delta.

Deltas are among the most important geographical features of the globe. They constitute the most fertile and populous plains of the earth, but, on account of their nature, are subject to overflows and to pestilential fevers. Consequently, they have been the scenes of many of the direst calamities that have ever befallen communities.

The control of the stream and the preservation of the land of deltas from overflow in order to keep open the rivers for navigation have been for ages among the greatest engineering problems presented to civilized countries.

The delta of the Mississippi—the most important in America—measures over 12,000 square miles, more than half of which consists of swamps, lagoons, and shallow lakes. The dry land is along the banks of the streams, and slopes back to swamps which lie between them.



Delta of the Nile.

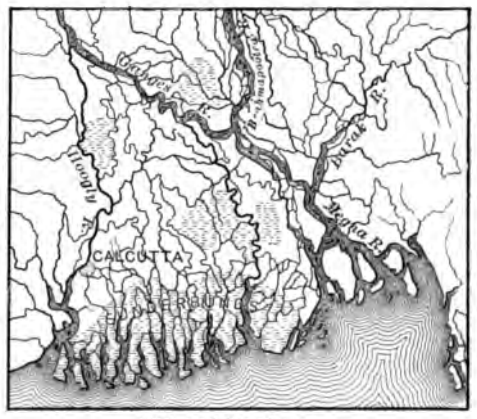
Most of the streams, or channels, are called *bayous*. Those near the mouths of the main river are called *passes*, and the artificial dykes along the river and the larger bayous are called *levees*.

The main river is from 50 to 200 feet deep in the delta until within a few miles of the Gulf, where it begins to meet the salt water. Here the stream further divides into several channels, or passes, each of which grows more shallow to its mouth, and in or just outside of which there are bars, forming a shoal, which entirely encircles the delta, obstructing navigation. Deep water for navigation is now maintained through the "South Pass" by means of "jetties," which increase the velocity of the current and check the influence of the salt water. The Gulf, about the mouths, is continually filling up, and the land is growing year by year.

The delta of the Rhine constitutes the rich and populous lands in Holland, and is the most important delta in Europe.

The most important delta of Africa is that of the Nile. It measures nearly 10,000 square miles, and has been noted for its fertility since the dawn of civilization.

The delta of the Ganges and Brahmapootra measures over 15,000 square miles, and has supported a dense population from remote times.



Delta of the Ganges.

But the largest and most populous delta in the world is that of the Hoang-Ho and Yang-tse rivers, in Eastern China. This extends nearly 700 miles from north to south, and has an area of 100,000 square miles. Its population is estimated at 100,000,000, living in several thousand villages and cities. It is veined by a network of channels and canals. The main river and larger branches are held in check by dykes, or "levees," built along the sides. As the bed of the river silts up these have to be built higher and higher, and at times of flood sometimes break, drowning the villages below.

For a century or two previous to 1853 the main mouth of the Yellow River was in the Yellow Sea, but in that year the river burst its dykes. Whole provinces were overflowed; there was an enormous destruction of property, and several millions of human beings perished. The river took a new course to the sea, and has since emptied its waters into the Gulf of Petchelee, 550 miles from the old mouth. This is the greatest geographical change on the globe in modern times. In September, 1887, there was another great overflow, accompanied with destruction of life and property, and it now seems as if the river will again take its course to the Yellow Sea.

All muddy rivers do not form deltas. Thus, the Amazon has no delta: its muddy waters are swept into the deeper sea by an oceanic current across its mouth.

21. **Estuaries.**—A single and very wide mouth of a river is called an estuary. Such are the mouths of the St. Lawrence, Columbia, Hudson, and other rivers in America; the Thames, Humber, Severn, and various other rivers of Europe.

Questions.—What is a river? A river-system? A basin? A divide? What is bifurcation? Upon what does the amount of water in a river depend? The length of the river? The velocity? What causes overflow? Falls and rapids? Describe the process of erosion. What are transportation and deposition? How are the different courses of a river distinguished? Describe these courses. What are sinuosities? What are deltas? Name some important deltas. What are estuaries?

III. The Drainage of the Continents.

22. The function of rivers is to drain the land. More water evaporates from the sea than from the land, but in proportion to its area more rain and snow fall on the land, especially on the mountains. More water falls upon the continents than is evaporated from them, and the surplus runs back to the sea in rivers. Most rivers must therefore empty their waters into the sea either directly or as tributaries to those which flow into the ocean.

But there are regions in each of the continents where the evaporation is as great as the rainfall, and where consequently there is no excess of water to run to the sea. The rivers in such regions flow into salt lakes or evaporate from the sands of deserts or dry up in some other way.

Such regions have a variety of names, and geographers have not agreed on any one term to include all. They are perhaps most generally known as "*interior-drainage basins.*"

This name is misleading, in that some such regions are table-lands, and that some are not in the interior, but on the coast, of continents. Some geographers call them "*steppes*," but that name is usually applied to certain portions of the interior-drainage basins of Asia and Europe.

Rivers have always been great highways of inland commerce, even since the building of railroads. They have therefore been of special importance in the history of nations.

The Atlantic Ocean, as has been stated, receives by far the largest number of the great rivers of the earth. The Arctic, Indian, and Pacific receive the others in about equal proportions. Their geographical distribution is more naturally considered in respect to the lands which they drain than to the ocean which they feed.

23. **Drainage of North America.**—The great divide of North America is the Rocky Mountain System and its southern continuation. This separates the Pacific slope from the Atlantic and the Arctic. The divide between the Atlantic and Arctic slopes is not a mountain-chain, but in the main only a swell of land so gentle in its slope as to be imperceptible to the traveler crossing it.

The Yukon (with a basin of 200,000 square miles), the Columbia (300,000 square miles) and the Colorado (260,000 square miles) are the chief river-systems emptying their waters into the Pacific, although many smaller streams, such as the Sacramento and Frazer, have commercial importance. The Mackenzie (580,000 square miles) is the chief river flowing into the Arctic Ocean.

The Saskatchewan (and Nelson), draining 472,000 square miles, and the Mississippi, 4200 miles long, the longest navigable river of the globe, and draining 1,240,000 square miles, flow into the Atlantic. Numerous smaller rivers, such as the Hudson and St. Lawrence, are of much commercial importance.

The chief area of interior drainage is the "Great Basin" between the Sierra Nevada and the Wasatch Mountains, entirely surrounded by regions which drain to the Pacific and extending nearly to the Gulf of California. It is about 900 miles long by 520 broad, and contains 217,000 square miles. It includes many distinct drainage-areas separated from one another by intervening chains of mountains. Some of these "basins" or "valleys" are plateaus over a mile above the sea, while portions of the Colorado Desert and Death Valley are actually below the level of the sea, and are the lowest depressions on the Western Continent.

There are many small rivers within the Great Basin, of which the Jordan and Bear rivers in Utah, the Humboldt, Carson, and Truckee in Nevada, and the Owen and Mohave in California, are the largest.

There are two smaller basins in Mexico, of which the Bolson de Mapimi is the greater.

24. **Drainage of South America.**—The Andes form the main divide, and lie so near the western side of the continent that there are no rivers of any considerable size flowing into the Pacific. This mountain-chain divides at the north, and between its two branches is the Magdalena River, whose waters empty into the Caribbean Sea, and which drains an area of 80,000 square miles.

The three great rivers of the Eastern slope are, respectively, the Orinoco on the north, with a basin of 340,000 square miles, and with its southern sources in the Parime Mountains of Guiana and Venezuela; the Amazon, near the equator, comprising the grandest river-system of the globe: it drains a region of 2,360,000 square miles, is nearly 3800 miles long, and is in places more than 50 miles wide; the La Plata, draining the Brazilian Plateau on the one side and the Andes on the other—an area of 1,380,000 square miles. It is an estuary with the enormous width of more than 80 miles.

The great plain extends continuously north and south across these three river-basins, and between those of the Amazon and Orinoco there is a navigable channel. (See page 45.)

The San Francisco and Tocantins, in Brazil, are also large rivers.

There are three areas not draining to the sea. The largest, on the plains of the Argentine Republic, has a season with some rain, and the water accumulates in shallow lakes which disappear in the dry season. There is a small region within the mountains in Bolivia in which the water drains into Lake Aullagas. The third is a small rainless district in the Desert of Atacama, west of the Andes, in Northern Chili.

25. **Drainage of Europe.**—All the chief rivers of Europe flow into bays, gulfs, seas, or inland lakes. In the north the Dwina and several lesser rivers flow toward the Arctic Ocean. Numerous rivers—none large, but some of considerable commercial importance—flow into the Baltic and North seas, the Bay of Biscay, and the Mediterranean Sea. The Danube, 1725 miles long and draining over 300,000 square miles, and the Dnieper, flow into the Black Sea. The Volga—the largest river of Europe, over 2000 miles long and draining 600,000 square miles—flows into the Caspian Sea.

The main divide of Western Europe is the Alps, from which the Rhine, the Rhone, the Po, and the Danube flow in different directions.

There is another great divide in the low forest-clad Valdai Hills in Russia where the Dwina and the Volga have their sources. The Volga falls but 637 feet in nearly 2000 miles of its course.

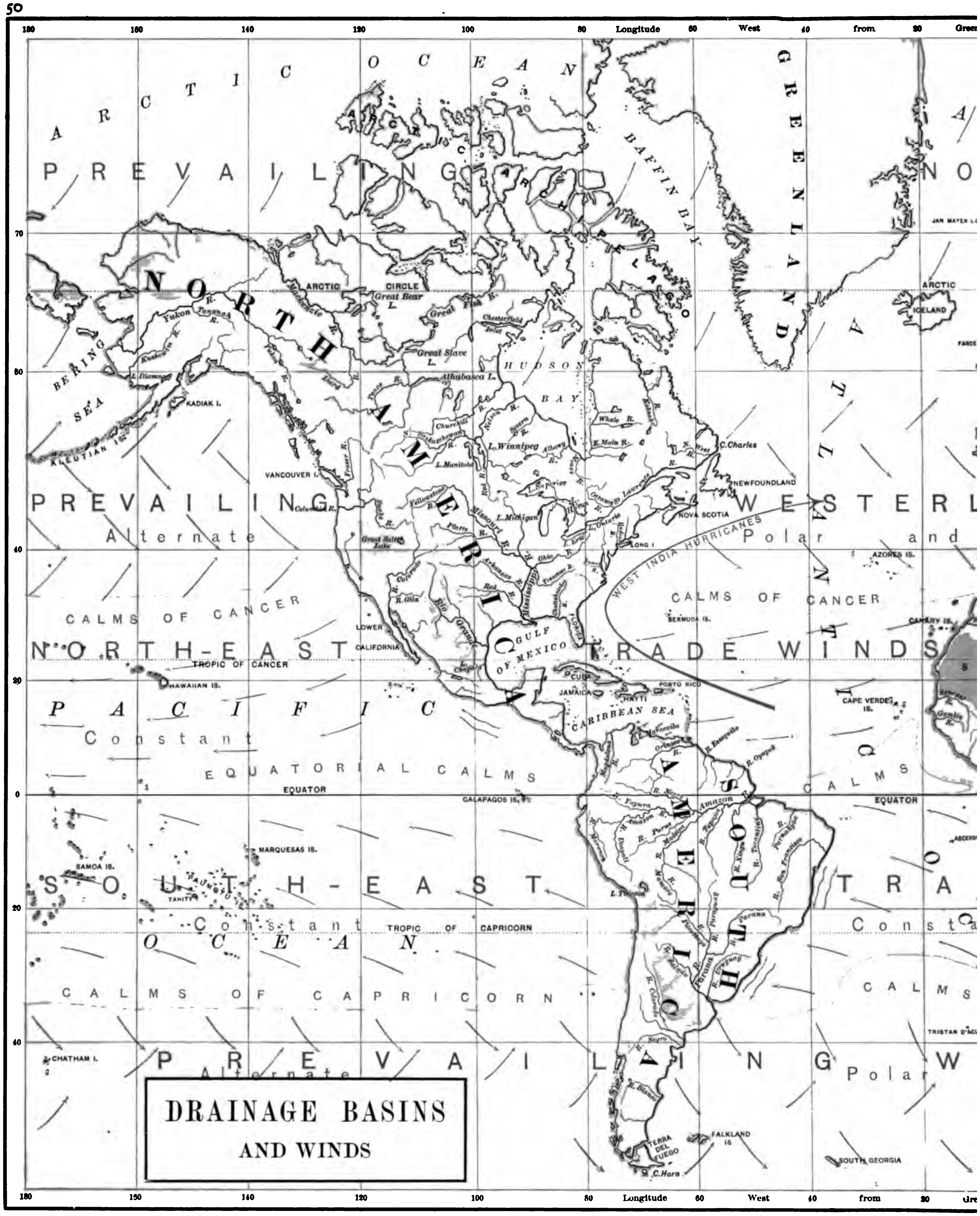
The region of interior drainage is continuous with that of Asia.

26. **Drainage of Asia.**—From the great height and extent of its mountain-systems, Asia has naturally many extensive river-systems. The Obi, the Yenisei (3400 miles long), and the Lena (2700 miles long) flow to the Arctic Ocean.

The Amoor, the Hoang-Ho (or Yellow River), the Yang-tse, and the Cambodia flow into the Pacific. The Yang-tse—3300 miles long and draining 950,000 square miles—is probably the third largest river of the globe.

The Irawaddy, the Ganges, and the Brahmapootra, each of the latter two draining over 400,000 square miles, flow from the Himalayas to the Bay of Bengal and the Indian Ocean.

The Indus—1850 miles long and draining over 400,000 square miles—reaches the same ocean by the Arabian Sea, and the Tigris and Euphrates, more noted for their historical associations than for their size, reach it by the Persian Gulf.


DRAINAGE BASINS
AND WINDS
Longitude West from Greenwich
ARCTIC OCEAN
PREVAILING
NORTH AMERICA
SOUTH AMERICA
GREENLAND
BAFFIN BAY
HUDSON BAY
BERING SEA
ALEUTIAN IS.
KADIAK I.
VANCOUVER I.
ARCTIC CIRCLE
Great Bear L.
Great Slave L.
Athabasca L.
L. Winnipeg
L. Manitoba
L. Superior
L. Michigan
Great Salt Lake
Yukon R.
Mackenzie R.
Columbia R.
Missouri R.
Mississippi R.
Ohio R.
Arkansas R.
Red R.
Rio Grande
Colorado R.
R. Gila
NEWFOUNDLAND
NOVA SCOTIA
C. Charles
LONG I.
BERMUDA IS.
AZORES IS.
CANARY IS.
CAPE VERDE IS.
ICELAND
JAN MAYEN I.
PREVAILING WESTERLIES
Alternate
Polar and
WEST INDIA HURRICANES
CALMS OF CANCER
NORTH-EAST TRADE WINDS
TROPIC OF CANCER
HAWAIIAN IS.
LOWER CALIFORNIA
GULF OF MEXICO
FLORIDA
CUBA
JAMAICA
HAYTI
PORTO RICO
CARIBBEAN SEA
PACIFIC
Constant
EQUATORIAL CALMS
EQUATOR
GALAPAGOS IS.
MARQUESAS IS.
SAMOA IS.
TAHITI
PAUMOTU
R. Amazon
R. Negro
R. Madeira
R. Parana
R. Paraguay
R. Uruguay
R. San Francisco
R. Tocantins
L. Titicaca
SOUTH-EAST TRADE
TROPIC OF CAPRICORN
OCEAN
CALMS OF CAPRICORN
PREVAILING
Polar
CHATHAM I.
TERRA DEL FUEGO
C. Horn
FALKLAND IS.
SOUTH GEORGIA
TRISTAN D'ACUNHA


East from Greenwich
20
40
60
80
100
120
140
160
180
O C E A N
ISLANDS OF NEW SIBERIA
North-East Cape
NOVA ZEMBLA
KARA SEA
E A S T E R L Y W I N D S
North Cape
L. Enara
FINLAND
L. Ladoga
L. Onega
White
BALTIC SEA
ARCTIC CIRCLE
Obi R.
Yenisei R.
Lower Tunguska R.
Upper Tunguska R.
Angara R.
Lena R.
Olenek R.
Kolima R.
Indighirka R.
Yana R.
Aldan R.
Vitim R.
L. Baikal
Amoor R.
OKHOTSK SEA
SAGHALIN I.
KAMCHATKA
KURILE IS.
YEZO
Volga R.
Ural R.
Kama R.
Irtish R.
Ishim R.
Tobol R.
Aral Sea
CASPIAN SEA
L. Balkash
BLACK SEA
Danube R.
Dnieper R.
Don R.
SICILY
CYPRUS
MEDITERRANEAN SEA
DESERT OF GOBI
THIBET
IRAN
ARABIA
Euphrates R.
Tigris R.
Indus R.
Ganges R.
Brahmapootra R.
Hoang Ho R.
Yang-tse-Kiang R.
JAPAN SEA
COREA
YELLOW SEA
KIUSHIU I.
NIPPON
TYPHOONS
FORMOSA I.
LUZON I.
MINDANAO I.
CHINA SEA
BORNEO
CELEBES
SUMATRA
JAVA
ARAFURA SEA
PAPUA
WINDS
Equatorial
C A L M S
TROPIC OF CANCER
NORTH-EAST TRADE WINDS
Constant
LYBIAN DESERT
RED SEA
Nile R.
L. Tchad
ARABIAN SEA
BAY OF BENGAL
CEYLON I.
MONSOONS
EQUATOR
L. Victoria Nyanza
L. Tanganyika
L. Nyassa
Congo R.
Zambezi R.
Orange R.
Good Hope
Mozambique Channel
MADAGASCAR
REUNION
MAURITIUS I.
HURRICANES
TROPIC OF CAPRICORN
CALMS
I N D I A N
W I N D S
O C E A N
CALMS OF CAPRICORN
AUSTRALIA
L. Amadeus
L. Eyre
Darling R.
Murray R.
TASMANIA
CORAL SEA
FEEJEE IS.
N. CALEDONIA
NEW ZEALAND
NEW ZEALAND SEA
PACIFIC OCEAN
W E S T E R L Y W I N D S
Equatorial and
KERGUELEN I.
Drainage Basins
Atlantic Ocean.
Pacific Ocean and Mediterranean Sea.
Arctic Ocean.
Gulf of Mexico, Caribbean, Baltic and China Seas.
Indian Ocean and Hudson Bay.
Basins without outlet.
Prevailing Winds.
North Easterly Winds.
Westerly Winds.
Trade Winds.
Monsoons.
Constant Calms.

The main divide is the Himalaya range, in the south; the lesser is the Altai, in the north. Between these mountain-systems is a great depression of interior drainage.

The main interior-drainage basin of Asia, which extends also far into Europe, is very much the largest on the earth. It extends over sixty degrees of longitude and thirty degrees of latitude. It is over 4000 miles in its greatest length and over 2000 miles in width. It includes several minor drainage-systems, the most notable of which is that occupied by the Caspian and Aral seas and their rivers. The Volga and Ural rivers empty their waters into the Caspian Sea, and the Oxus and Sihon into the Aral Sea. The eastern portion extends into the elevated desert of Gobi, and to other plateaus of Central and Eastern Asia.

A portion of the Plateau of Arabia is without drainage to the sea, and another small depression, in Western Palestine, noted as being the lowest portion of the earth's surface, is 1300 feet below the level of the sea.

27. **Drainage of Africa.**—The interior of tropical Africa is a great plateau with a heavy rainfall, and from this region three great rivers run in three different directions. The Nile, the most celebrated river of history, flows northward to the Mediterranean. It has a total length estimated at over 4000 miles, and is the second longest river on the globe. As the last 1800 miles of its course lie in dry regions, it receives no tributaries for nearly one-half of its entire length.

The Zambezi flows southeasterly to the Indian Ocean, and is 1800 miles long. The Congo, the first river of Africa, and probably the second on the globe in volume of water, is about 3000 miles long, and flows westerly to the Atlantic.

The Orange River of South Africa, flowing to the Atlantic, and the Niger, flowing into the Gulf of Guinea, are the other chief rivers of this continent.

There are two areas of interior drainage. The smaller one is south of the equator, between the sources of the Zambezi and Orange rivers, where a few small rivers flow into the shallow Lake Ngami. The greater basin is north of the equator, and includes the table-land of the Sahara Desert and the depression in Soudan occupied by Lake Tchad, which receives several rivers, two of which are of considerable size.

28. **Drainage of Australia.**—This continent has only low mountains and comparatively few rivers of any great size. The main divide lies near the eastern coast, and the streams that flow into the Pacific are short.

The longest and greatest river of this continent is the Murray, 1500 miles long. Its numerous tributaries drain the western slope of the Blue Mountains, and, flowing southward, it discharges its water into an immense lagoon which has imperfect communication with the Indian Ocean. A large portion of the interior is a plain with scanty soil too dry for rivers. The small streams formed during the wet season flow into shallow ponds, most of which disappear during the dry season.

Questions.—What is the function of rivers? Where does the greater evaporation occur—on the sea or on the land? Which receives the greater amount of rainfall? What becomes of the excess of water? Do all regions have a surplus? Which ocean receives the greatest part of the drainage of the earth? What forms the great divide of North America? Name some of the important rivers. Where are the interior basins? What is the main divide of South America? Describe the important rivers. The interior basins. What is the peculiarity of the chief rivers of Europe? Describe the drainage of Asia. Of *Africa*. Of *Australia*.

IV. Lakes.

29. **Lakes** are bodies of water collected in depressions of the land. They may be divided into two classes—those which contain fresh water and those which contain salt water. Salt lakes have no outlet, and sometimes disappear in dry seasons.

The existence of lakes depends in part upon the geological structure of the country, in part upon the amount of denudation and erosion it has undergone, and in part upon the climate and rainfall.

Lakes include a great variety of bodies of water. Some are mere expansions of a river, and are obviously but a part of the stream, such as Lake Pepin on the Mississippi; some have an extended basin into which the waters of the main stream flow, and from which they issue again at its outlet: such are Lake Geneva on the Rhone and the chain of Great Lakes north of the United States; still others are reservoirs, receiving many rivers. Some are very deep and have their bottoms below the level of the sea, others so very shallow as to be scarcely more than swamps. Some remain at nearly the same level throughout the year, others fluctuate greatly with the season, and some even dry up entirely during droughts. In composition their waters vary from a condition of almost absolute purity to one of a saturated solution of salts, and from a state of great clearness to one of almost opaque muddiness.

Owing to this great variety of character lakes have been variously classified. For geographical study the division into fresh- and salt-water lakes is the best, but for geological study they are better divided into three classes, according to their origin—viz.: (*a*) those caused by the bending or breaking of the strata; (*b*) those occupying valleys of erosion; (*c*) those of more recent origin, which may be called natural dams, such as the shallow lakes in deltas and many in glacial drift soil.

Lakes are sometimes called seas in popular literature, as the Dead Sea and the Sea of Galilee. This use of the word comes into our language from the root of the German *see*, which means "lake." The term *lagoon* is applied to shallow lakes (or even to creeks) more or less connected with the sea, or with a river in low-lying regions, particularly in deltas.

30. **Salt Lakes** occupy interior drainage-basins and are without outlets. They are salt because river-water is never chemically pure, and these lakes, losing water by evaporation, retain the salt and other dissolved materials brought into them by their affluent rivers.

Salt lakes vary in their character even more than fresh lakes. In saltness they are of every grade, from those merely brackish to those which are saturated solutions containing more than one-third of their weight of salt. In some the salt is very pure (*sodium chloride*), and great quantities of salt are manufactured by evaporating the water of such lakes; others contain mixtures of many substances. Carbonate of soda is obtained from Soda Lake in Nevada and Owen Lake in California; borax and other substances are obtained from certain other lakes.

Some salt lakes are of very great depth; others are shallow and dry up in the summer, leaving beds of salt, "alkali," or mud. *Playa* lakes are of this class, and are broad, shallow sheets of water which dry away; the term "*playa*" is applied to the smooth, dried mud-plain which remains.

Some salt lakes are found on very high plateaus; others occur in the very deepest depressions of the earth's surface.

31. Lakes having an outlet and containing fresh water are more numerous than those without outlets, and they occupy well-defined regions. Small lakes are found in nearly every mountain-region of the world, and contribute one of the most picturesque features to mountain-scenery.

32. The **Lake-Region of North America** is the most extensive on the globe, and sweeps in the shape of a broad belt around Hudson Bay from Labrador to the shores of the Arctic Ocean. To it belong the numerous lakes of Canada, the New England States and New York, the Great Northern lakes, the small lakes in Minnesota, and the many large and small lakes east of the Rocky Mountains.

The actual number of lakes in this region is very large. There are over one

36. **Africa.**—There is a lake-region on the plateau of eastern tropical Africa where, at altitudes varying from 2500 to 4000 feet, are large lakes which feed the great rivers of the continent. Albert Nyanza, Victoria Nyanza, and Albert Edward Nyanza feed the Nile, which flows northward to the Mediterranean; Lake Nyassa empties through the Zambezi, which flows south-easterly to the Indian Ocean; and Lakes Tanganyika and Bangweolo are the sources of the great Congo, which flows westward to the Atlantic. Lake Tchad, in Soudan, is reputed to contain fresh water. It is 200 miles long and 100 miles wide, and is 800 feet above the sea.

Victoria Nyanza is over 3800 feet above the level of the sea, and its estimated area is from 20,000 to 26,000 square miles, or nearly the same as that of Lake Michigan. Its depth is about 300 feet. By means of a large stream, abounding in falls and rapids, it is connected with Albert Nyanza, another great sheet of water, supposed to be as large as Lake Huron.

There are no large salt lakes in Africa. There are numerous shallow salt or brackish lakes in the Desert of Kalahari, south of the equator, of which Lake Ngami—about 3000 feet above the sea—is the largest.

The soil of Africa is singularly deficient in salt. Lake Ngami is fresh in the rainy season, but covers much less surface in the dry season, and is then brackish; and the other lakes of this desert are described as brackish rather than salt. Lake Tchad, which receives several rivers, is said to be without outlet, and to be fresh. If these statements are true, this lake is a rare example of the kind. The true explanation of the freshness of the lake is probably the fact that during the rainy season the surplus water overflows.

37. **Australia** is more destitute of lakes than any other continent. There are many salt or brackish lakes, of which Lake Torrens and Lake Eyre, 3000 to 4000 square miles in extent, are the largest. Many of the small lakes dry up entirely in the dry season.

38. **Swamps** are areas of level land saturated or partly covered with water. The large swamps occur chiefly in the great continental low plains, but the smaller ones are found wherever there is the requisite water and a level tract of land. North America has many large swamps. The Great Dismal Swamp in Virginia, the Alligator Swamp between Albemarle and Pamlico sounds in North Carolina, Okefinokee Swamp between Georgia and Florida, the Everglades in Southern Florida, and the swamps of the Mississippi delta, are examples.

In South America vast swamps extend along the eastern base of the Andes and the valley of the Amazon River. In the rainy season they present the appearance of inland seas.

In Europe are the great Rokitno Swamp in West-Central Russia, the extensive salt marshes around the Caspian Sea, the Pontine Marshes near Rome, and the Maremma near Florence, dreaded on account of their malarious exhalations.

In Northern Siberia and Russia are the "Tundras," the most extensive swamps on the globe. They are frozen to a great depth, and, thawing during the short summers at the surface only, are then clothed with a dense covering of grass and mosses. There are also great "Tundras" in Northern Alaska and the Northwest Territory.

Questions.—Upon what conditions does the existence of lakes depend? How do lakes vary in character? How are they classified for geographical study? For geological study? Where are salt lakes found? Why are they salt? What mineral substances are found in some of these lakes? What is said of the lake-region of North America? How are the lakes distributed? What proportion of the fresh water of the globe is found in the chain of Great Lakes? Name the two most important lakes of South America. What two lake-regions in Europe? Name some of the most famous lakes. Which is the largest fresh-water lake of Asia? Name some of the noted salt lakes of Asia. Where are the large lakes of Africa situated? What is said of the Australian lakes? Name some of the large swamps. What are "Tundras"?

V. The Ocean.

39. The **Ocean,** or **Sea,** is that great continuous body of water which surrounds the continents and covers about three-fourths of the earth's surface. The water of the ocean contains nearly three and a half per cent., by weight, of various mineral substances, chiefly chloride of sodium or common salt.

Other substances are also found dissolved in sea-water, but only in minute quantities. These various ingredients impart a salt taste and render it unfit for drinking. A cubic foot of fresh water weighs sixty-two and a half pounds; the same quantity of sea-water weighs about sixty-four pounds. Fresh water freezes at 32° Fahr.; sea-water, at 27°.

The water in all parts of the ocean is not equally salt, owing to differences in evaporation and in rainfall, to proximity to the mouths of great rivers, and to other causes.

The mineral substances which give to sea-water its peculiar briny taste are solids held in solution by the water, but, in addition to these, large quantities of the various gases which compose the atmosphere are dissolved and diffused throughout the depths of the ocean.

40. The **Cause of the Saltness** of the ocean is the continuous supply, from the land masses, of water more or less charged with saline ingredients, as well as the continuous evaporation from the surface. As water when it is transformed into vapor becomes pure and parts with all solid matter which it formerly contained, it is evident that the ocean, like a lake having no outlet, would eventually become salt, even if its water was originally fresh. It is very generally believed, however, that the ocean has always been salt. While the earth was in the molten state described on page 11, the water and many other substances which are now solids or liquids must have existed only as gases in the atmosphere. As the cooling took place, the first rain-storms would consist of hot water, which in its passage through the dense atmosphere would dissolve large quantities of the mineral gases; and as the condensation of the water vapor continued, the sea would at the beginning contain mineral matter in solution.

41. The **Color of Sea-Water** varies in different parts of the ocean. Small quantities—as, for instance, a glassful—are as colorless as the purest spring-water, but large quantities are blue. The deep ocean is an intense blue, and the shallower portions near the shore are green. Some parts of the ocean show particular local colors, probably occasioned by impurities. The Gulf of California, the Red Sea, and the Arabian Sea are somewhat red; the Persian Gulf is green; the Yellow Sea, yellow; and the sea near Bombay, a light rose-tint.

42. The **Clearness** and **Transparency** also vary greatly in different localities. Bright objects are visible in the clearest water to a depth of about 150 feet.

The sea is seldom penetrated by the sun's rays to a depth greater than 300 feet. "The depth-limits of absolute darkness" have been determined in some Swiss lakes (by photography) to be from 300 to 350 feet, but ocean-water is clearer, and some light penetrates to a depth of 600 feet (100 fathoms), or possibly to even a greater depth.

43. The **Phosphorescence** of the sea owes its origin to myriads of minute animals that shine like glow-worms, particularly when the water is agitated.

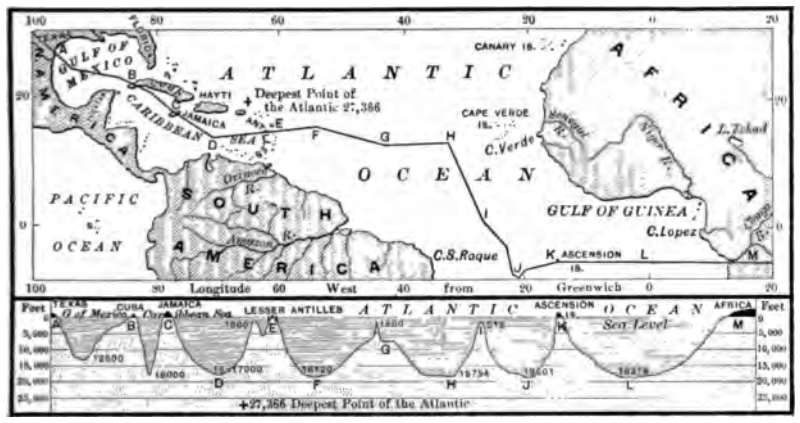
This beautiful phenomenon is most common in warm seas, and is thus described by Mr. Darwin: "While sailing a little south of the La Plata on one very dark night the sea presented a wonderful and most beautiful spectacle. There was a fresh breeze, and every part of the surface which during the day is seen as foam now glowed with a pale light. The vessel drove before her bow two billows of liquid phosphorus, and in her wake she was followed by a milky train. As far as the eye reached the crest of every wave was bright, and the sky above the horizon was illuminated from the reflected glare of these lurid flames."

44. The **Average Depth** of the sea is about 12,000 feet (2000 fathoms). There are large areas where it is more than 18,000 feet (3000 fathoms), and a few places of limited extent where the depth is more than 24,000 feet. The greatest known depth is in the Western Pacific Ocean, and is 27,930 feet, or over 5¼ miles.

Only during late years have the means of accurately measuring great depths been known. All the earlier soundings of more than 1000 fathoms are very inaccurate.

The depth, as one moves away from the continents, increases more slowly for the first thousand fathoms than for the succeeding depths. The continents, with their continental islands, appear to occupy great plateaus with steep sides.

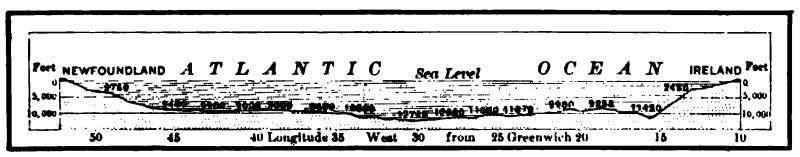
The few profound abysses over 24,000 feet deep are narrow valleys at one side (the western) of the oceans, and in their relation to the bed of the ocean may be compared with the highest peaks of the Andes and the Himalayas.



Section across the Middle Atlantic Ocean.

The diagram represents, in the upper map, a line along which soundings have been taken from the Gulf of Mexico to the coast of Africa, and in the lower vertical section the corresponding depths of the sea are shown.

45. The **Bottom of the Sea,** like the land, is diversified by mountains and valleys and has its plains and plateaus. It is not, however, so rough as the land, and the slopes are more gentle. The undulations are due to the great movements of the earth's crust, and not to erosion; on the contrary, deposition is going on, filling up the hollows.



Bed of the Atlantic between Newfoundland and Ireland.

The bed of the Atlantic Ocean between Ireland and Newfoundland has been frequently surveyed; it is shallow when compared with the greater depths to the south. The result of the soundings showed the sea-bottom to be so even that the laying of telegraphic cables became a practical project. This portion of the Atlantic bed, which is shown in the above diagram, has been appropriately named the "Telegraphic Plateau."

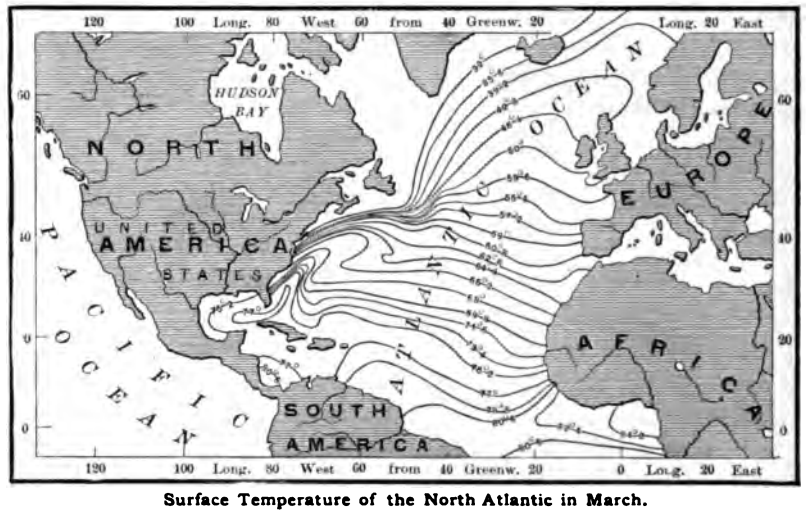
The character of the bottom (except when rocky) varies with the depth and the distance from the continents. In the warm seas, if the water is shallow, coral and marine growths form the material. Near the continents, and for a distance of 200 miles, or even more, if the water is not deep, the bottom is sandy, pebbly, or muddy, and modified by the neighboring land.

Beyond this shore-belt (except in the colder seas) and where the water is less than 15,000 feet deep much of the bottom is a soft "ooze" made up of the remains of the creatures, mostly microscopic, which have lived near the surface and whose shells contain much lime. Some of these microscopic shells are of exceeding beauty. At depths of 15,000 feet and more the bottom is composed of a very fine red or brown clay.

In places submarine volcanoes modify the bottom. For example, about 500 miles from the coast of California there is a sharp mountain, 13,000 feet high, which rises to within 2000 feet of the surface, while the water all around it is over 15,000 feet deep.

46. **The Temperature of the Sea.**—The temperature of the surface of the ocean ranges from 30° to 85°. Throughout much of the Torrid Zone it is from 76° to 80°, and in a few limited areas it rises to 85°; in the Frigid Zone it ranges from 30° to 40°, sinking to 28°, or even lower, in winter. In the Temperate Zones it varies greatly in the same latitudes, owing to differences of climate, winds, and currents.

This great range of temperature is found only near the surface; at the bottom of the deep sea it is much more uniform, and everywhere very cold. The common temperature is 35° or 36°, falling in some places to 31°.



Surface Temperature of the North Atlantic in March.

Fresh water, when cooled, shrinks in bulk until it reaches about 39½°, at which temperature it has its greatest density; when cooled below that, it expands again until it reaches the freezing-point, when the ice expands still more. Therefore ice not only floats on water, but ice-water floats on water of 40°. The water on the bottom of deep lakes in cold climates is therefore about 40°. Sea-water behaves somewhat differently: it shrinks obviously, on cooling, to about 35°, below which temperature the density remains nearly the same, decreasing but slightly, until it freezes at about 27½°. The cold sea-water of the polar regions sinks and flows into the deep abysses of the oceans.

In the warm seas, if the temperature is taken at successive depths, it is found that the water grows colder with the descent, until at length water of uniform temperature is reached, which continues to the bottom. At the equator this limit of decreasing temperature is at the depth of 10,000 or 12,000 feet, but the depth is less and less toward the poles, until it reaches the surface in the cold waters of the polar regions.

47. **Divisions of the Ocean.**—Although the ocean is in reality but one continuous mass of water, for convenience of description it is separated, partly by the continents and partly by imaginary lines, into five divisions—the Arctic, Antarctic, Atlantic, Pacific, and Indian oceans.

48. The **Arctic Ocean** surrounds the north pole, and is bounded by the northern coasts of North America, Asia, and Europe, and by the Arctic Circle. It is connected with the Pacific Ocean by Bering Strait, with the Atlantic Ocean by the Greenland Sea, between Greenland and Norway, and by Baffin Bay and Norton Sound. It is the smallest of the five divisions, and occupies but $\frac{1}{35}$ of the oceanic area.

Little is known of its depth, except that it is the shallowest of the oceans.

49. The **Antarctic Ocean** lies around the south pole and extends to the Antarctic Circle. It has no land-boundary at all, and is not naturally separated from the Atlantic, Pacific, and Indian oceans. It is the fourth in size, and occupies but $\frac{1}{17}$ of the oceanic area.

We have no knowledge of the extent of the lands in this Antarctic region; but the ice-cap which surrounds the south pole is much more extensive than that of the so-called "Palæocrystic Sea" around the north pole.

50. The **Atlantic Ocean** is the second in size. It occupies about ¼ of the oceanic area, and lies between Europe and Africa on the east and North and South America on the west.

The South Atlantic is distinguished by the absence of large bays; the North Atlantic, on the contrary, projects many bays and gulfs, the most important of which are the Gulf of Mexico, Hudson Bay, and Baffin Bay in North America; the Mediterranean Sea and the Baltic Sea, with the gulfs of Bothnia and Finland, in Europe.

It has three great border seas—*i. e.*, seas separated from the ocean by island-chains—viz., the Caribbean Sea and Gulf of St. Lawrence in North America and the North Sea in Europe.

On account of these numerous indentations, the Atlantic has a more extensive coast-line than any other ocean, and reaching, as it does, the most enlightened nations of the world, it has been for many years the great highway of commerce.

A narrow abyss near its western edge, 27,366 feet, or about 5⅕ miles, below the surface, is its deepest part. The Southern Atlantic is, as a whole, deeper than the Northern Atlantic, and its bottom is colder.

The bed of the Atlantic consists of two valleys, extending nearly north-and-south. These depressions are approximately parallel, and lie on opposite sides of an elevated plateau, the highest summits of which form the islands of this ocean.

51. The **Pacific Ocean** is as large as all the other oceans combined; it is bounded on the west by Asia and Australia, and on the east by North and South America.

It has five great border seas. At the north is Bering Sea, with the Aleutian Islands; on the west are the Sea of Okhotsk, with the Kurile Islands; the Sea of Japan, with the Japan Islands; the North China Sea, with the Liu Kiu Islands and Formosa; and the South China Sea, with the Philippine and Molucca islands. Its east or American side has no large gulfs, except that of California.

Its deepest place is a narrow abyss on the western side, off the Kurile Islands, 27,930 feet. There is an abyss between the Ladrone and Caroline islands 26,850 feet deep, and another off the coast of New Guinea 26,700 feet deep. The average depth has been computed to be from 14,000 to 15,000 feet.

52. The **Indian Ocean** is the third in size, and occupies about ⅕ of the oceanic area. It extends from the Antarctic Circle northward to Asia, and is bounded on the west by Africa and the meridian of the Cape of Good Hope, and on the east by Australia and the meridian of South Cape, in Tasmania. The Red Sea, the Arabian Sea, the Persian Gulf, and the Bay of Bengal are its most important bays.

Its greatest depth is in the northeastern part, between Java and Australia.

53. Attention has already been directed to the existence of a land and a water hemisphere. The greater part of the land occupies the Northern Hemisphere, while the great bulk of the ocean is accumulated around the south pole as a center. With the exception of the unexplored Antarctic Continent, scarcely any land breaks the continuity of this vast expanse of water till it reaches the southern extremity of South America. The Indian, Pacific, and Atlantic oceans then extend toward the north as great continuous arms of this southern sea. The Indian and Pacific oceans are practically enclosed by the land masses, while the Atlantic, through its connection with the Arctic Ocean, penetrates to the north pole.

Questions.—How does the composition of sea-water differ from that of fresh water? What causes the saltness of the ocean? What is the color of sea-water? What is said of its transparency? What is the cause of its phosphorescence? What is the average depth of the sea? The greatest known depth? What is the character of the sea-bottom? What is the range of the surface temperature? The common temperature at the bottom? Describe the difference between the freezing of fresh and salt water. Where is the line of uniform temperature? What arbitrary divisions of the ocean are made? Name and describe these divisions. What is said of the continuity of the ocean?

VI. Waves and Tides.

54. The ocean is never still. It is moved by **Waves, Tides,** and **Currents.** They are produced by different causes and have no connection with one another, although all may appear together.

55. **Waves** are the successive ridges of water produced by the wind. Wave-motion is not an onward flow of the whole mass of water, as in a river; it is the ridge that moves forward, while the particles of water rise and fall without changing their locality.

When the wind passes over a field of growing wheat, every ear bends under its pressure, and immediately straightens up again. The waves which we thus observe in the wheat-field are, therefore, formed by different ears in successive order. In a similar manner the waves of the ocean rise and fall, and the water which forms them flows a little in the manner of the ears in the field. Mathematically, each particle of water moves in a small circle or ellipse the size of which is related to the height of the wave. Strictly speaking, there are several kinds of waves. The tides are, in fact, waves of great breadth, as are earthquake-waves.

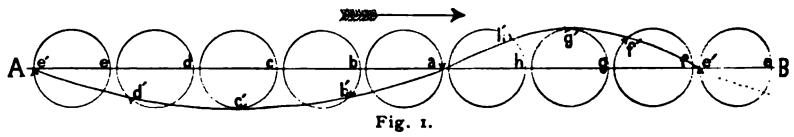


Fig. 1.

The diagram, Fig. 1, illustrates the circular movement of particles of water in the progressive motion of a wave. The straight line *AB* represents the surface of the water when at rest; the curved line shows the undulating surface of a wave which moves from *A* toward *B*. Each particle moves in its orbit in the direction of the hands of a watch, and at the instant under consideration the particle *a* is in its normal position. The particles which were at *b*, *c*, *d*, and *e* respectively have moved to *b′*, *c′*, *d′*, and *e′*. The particle at *c′* has reached the lowest part of the trough of the wave, and that at *e′*, having made half a revolution, has returned to the normal level. Simultaneously, the particles at *h′*, *g′*, and *f′* are above the level in their motion toward *h*, *g*, and *f* respectively; *g* having made three-fourths of a revolution is at the crest. Waves break when the water becomes too shallow for the particles to complete that part of the revolution which is below the normal level.

56. The **Height of Waves** depends on the force of the wind and the depth and extent of the sea. Waves in fair weather and in mid-ocean are from 6 to 10 feet high. Ordinary storm-waves are from 20 to 35 feet, but in great storms they have been measured and found to reach the height of 60 feet.

57. The **Distance between the Crests** of two successive waves is called the *breadth*, and bears no relation to the height. In ordinary storm-waves it is from 400 to 1000 feet. The very longest distance is about half a mile.

58. The **Velocity** with which the wave-movement travels depends chiefly on the breadth of the wave and the extent and depth of the sea. Waves in fair weather and in the open sea, 5 to 10 feet high and 50 to 100 feet broad, travel 10 to 20 miles per hour. Ordinary storm-waves travel 25 to 40 miles per hour, though a velocity of 60 miles has been reported.

Wind-waves affect only the surface—that is, the actual motion is greatest at the surface and diminishes rapidly with the depth. The great waves off the Cape of Good Hope, 40 feet high and a quarter of a mile broad, at the depth of 1000 feet would scarcely move a grain of sand.

But tidal waves and the great earthquake-waves affect every portion of the deepest parts of the sea; and the deeper the water, the greater their velocity. The waves of a Japanese earthquake traveled across the Pacific Ocean at an average rate of 390 miles per hour. When they reached California, they were less than a foot high, and were over 200 miles broad. From these waves Professor Bache calculated that the average depth of the Pacific was 2½ miles, and soundings since have confirmed his calculation.

The great earthquake-waves from Arica, Peru, in 1868, traveled to Sydney, 7440 miles, at the rate of 314 miles per hour, and to Honolulu, 5580 miles, through deeper water, at the rate of 454 miles per hour.

59. **Breakers.**—When a wave coming from the deep sea reaches shallow ground, the progress of its base is retarded, while its crest moves on, curls over, breaks, and rushes forward with a velocity depending upon the character of the wave. Waves of this description are called *breakers*.

During a storm in February, 1888, the breaking waves dashed over the tower of the lighthouse on Tillamook Rock, near the mouth of the Columbia River, 140 feet above sea-level, and broke the glass of the lantern. On the rocky coast of Scotland breakers have been known to dash 250 feet high.

The force with which breakers dash upon the shore is dependent upon the direction and the strength of the wind and the expanse of water which has been exposed to its energy. When the wind blows from the sea, the waves are more powerful than when the wind is off the land. In great storms the waves acquire an irresistible force, and are instrumental in wearing away the rocks and changing the character of the coast-line.

At the French port of Cherbourg the power of storm-waves was illustrated, during a violent tempest, by the fact that stones weighing nearly 7000 pounds were thrown over the top of the breakwater, which is a bank of rock surmounted by a wall 20 feet high. There are instances recorded in which masses of rock weighing many tons have been moved by the force of the waves.

The beating of the billows against a rocky shore breaks the rocks in pieces and pounds the fragments into sand, which in turn is finally ground to powder, in connection with other material which collects on the beach, and is distributed in the deeper water.

60. When the shore rises perpendicularly from deep water, the incoming waves do not break, but simply rise and fall without much commotion. Advantage has been taken of this fact in building vertical walls as breakwaters for the protection of harbors.

61. After the wind which has lashed the surface of the sea into waves has subsided, the motion or *ground-swell* of the ocean does not cease, and a long-continued calm is necessary to produce a smooth sea.

62. The **Tides** are that movement of the ocean which is seen in the regular rising and falling of the water along the shores each twelve hours.

Tides may be observed anywhere on the sea-shore except on bays connected with the open ocean by a comparatively narrow channel or strait. For about six hours the water rises; this is called *flood-tide*. It then remains stationary for a few minutes; this is called *high water*. Then the water gradually falls, causing *ebb-tide*, and again has a period of rest, which is called *low water*. Flood- and ebb-tide together last twelve hours and twenty-five minutes.

63. The tides are, in fact, broad waves that move around the earth. They are caused by the attractive force with which the moon and the sun act upon the earth. The attraction of the moon is the chief cause.

Attraction is that power which draws or pulls bodies toward one another. The earth attracts the moon; the sun attracts the planets. But this force acts reciprocally, and hence the moon also attracts the earth. This attractive force—called the *attraction of gravitation*—diminishes when the distance between the attracting bodies becomes greater.

The deepest oceans are but a thin layer of water, compared with the whole solid mass of the earth. The attraction of the moon is the greatest on the side of the earth nearest to it, and the water, being free to move, is drawn up in a broad swell or wave directly under it. This wave follows the moon around the earth, and produces one tide each day.

The attraction of the moon is least on the side of the earth farthest from it; hence the tendency is to draw the solid earth away from the water on that side. As a result, another broad swell or wave is produced on the farther side from the moon, and thus the second tide each day is produced.

But the sun is also instrumental in making the tides; its tide-producing power is to that of the moon as 355 to 800. In other words, the power of the moon is between two and three times greater than that of the sun, owing to her greater proximity to the earth.

The two subjoined figures illustrate the combined effect of the sun and the moon in producing the tides.

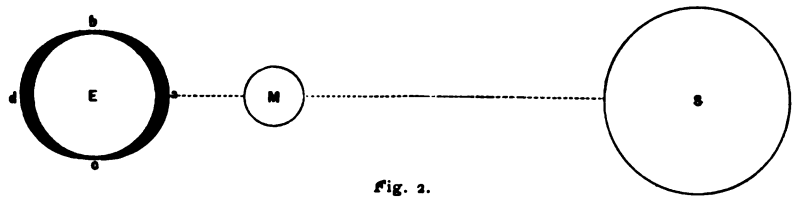


Fig. 2.

In Fig. 2, E is the earth, M the moon, and S the sun; *a*, *b*, *c*, *d* is the water covering the earth. Earth, moon, and sun stand in a straight line. Moon and sun raise the water at *a*, and also at *d*, because the solid earth is drawn away from *d* toward the moon.

The attractive force of the two heavenly bodies acting conjointly produces the highest tides—which are called *spring-tides*—at *a* and *d*, while at *b* and *c* there is, at the same time, low water.

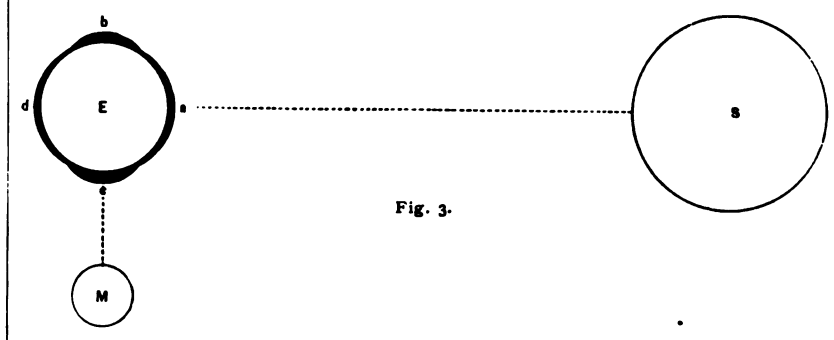


Fig. 3.

In Fig. 3 the sun and the moon are acting at right angles, and the attractive force of each is exerted in a different direction. The moon produces tides at *c* and *b*, while the sun also produces tides at *a* and *d*. Those caused by the sun are, however, insignificant, and merely reduce the size of the tidal waves at *c* and *b*. These are called *neap-tides*.

As the moon revolves around the earth once in about twenty-eight days, and is twice during that time in line with the sun and twice in such a position that their forces conflict, it follows that the character of the tides changes each week, and that two spring-tides and two neap-tides occur each month.

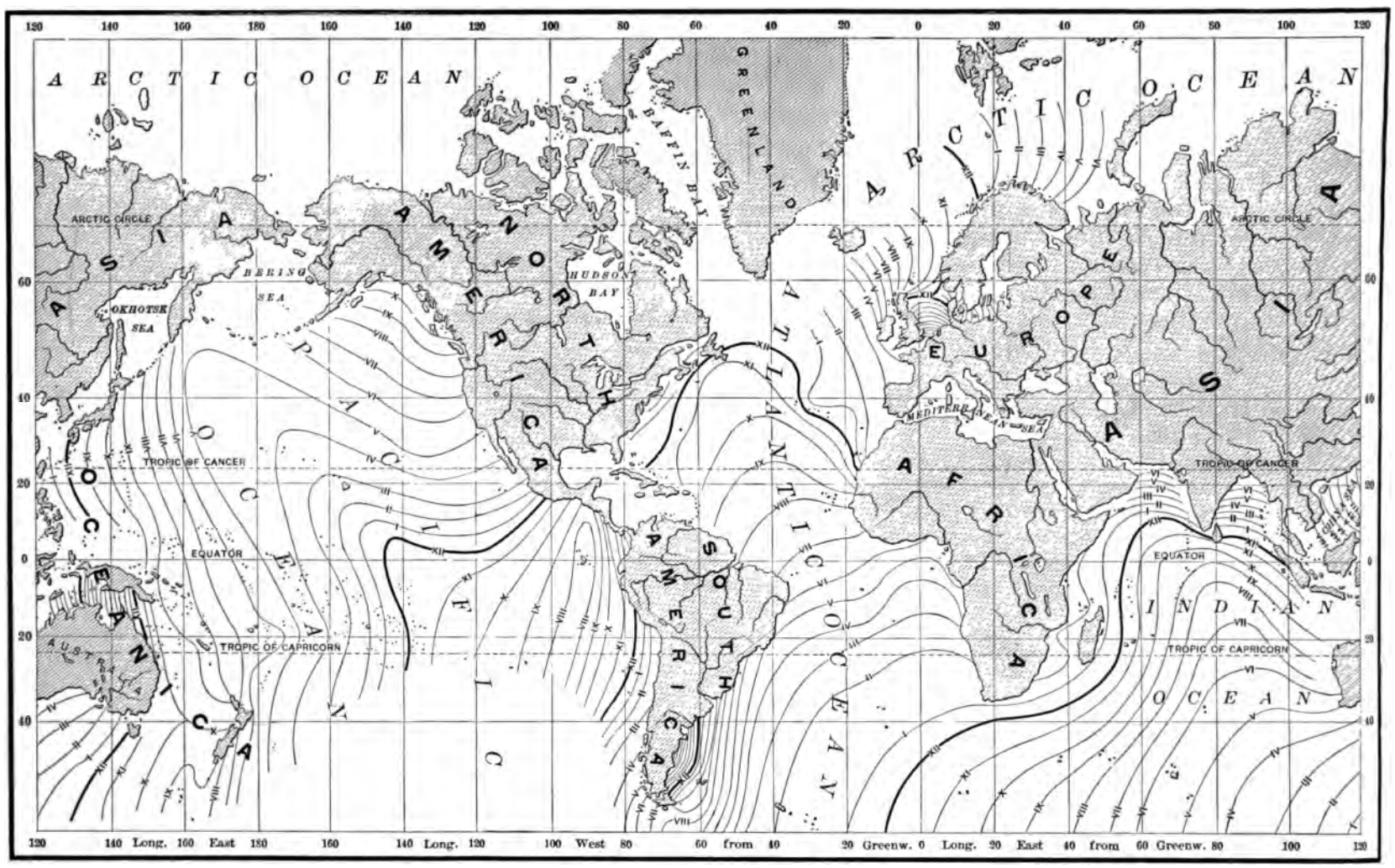
The heights actually reached at high and at low water are greatly modified by the force and direction of the wind. Heavy storms may cause the rise or fall to be several feet more than the usual tide, especially in bays with wide mouths.

On account of the friction of the water, the highest tides do not take place exactly at the time when the moon is exerting its greatest influence. The maximum height of the tidal wave is observed somewhat later, and is due to the accumulated momentum of the water and to friction with the bottom.

A knowledge of the movements of the tidal waves in harbors is necessary for safe navigation. The laws which control these movements are simple, but so many different influences complicate the ebb and flow that the actual times of high water, the amount of rise and fall, and the strength of the currents can be determined only by many careful observations made at each place.

64. If the earth were a true sphere and evenly covered by a layer of water, the tides would follow the moon like a broad but gentle swell. But vast continents divide the ocean into distinct basins, and these basins vary in depth; hence the progress of the tides is more complicated.

In small basins and inland waters the water cannot be gathered together into a great tidal wave. Even the Atlantic Ocean is not wide enough to give full scope to this phenomenon. It is in the vast and deep water-area which consists of the Antarctic, Southern Pacific, and Indian oceans that the great wave is produced, and from



Cotidal Chart, showing the Course of the Tidal Wave.

here it follows the moon on her apparent westward journey around the earth, sweeping up against the African and Asiatic coasts into the Atlantic Ocean and around Cape Horn into the Pacific Ocean.

The tidal wave, like great earthquake-waves, moves fastest where the ocean is deepest (see paragraph 58), and, like other waves, it is not an onward flow, except over shoals and near the land.

65. **Cotidal Charts** are made by connecting with lines all those points in the oceans which experience the arrival of the tidal wave simultaneously.

The above chart represents these **Cotidal Lines** as they progress from east to west. The birth-place of the parent wave is assumed to be south or southeast of the island of Tasmania, and, as has just been stated, there are few obstacles to oppose its progress in the waters of the southern oceans; its onward motion is therefore most uniform in that great expanse. Starting, then, at the lower right-hand corner of the chart, the movement of the tides may be followed. The spaces between the cotidal lines, proceeding from east to west, indicate the progress which the tidal wave makes each hour, and in twenty-four hours and fifty minutes from the time it started from Tasmania it will reach that point again.

An examination of the chart will show that the tidal wave in the Indian and Atlantic oceans is but a continuation of the parent wave. If any tides are created directly in these basins, they are overpowered or merged into the more powerful motion from the south; the direction is somewhat changed by the depth of the water and the form of the coast-lines. The upper part of the wave, retarded to some extent along the southern coast of Australia, is deflected toward the north, and advances with considerable velocity toward the shores of India. As it approaches the coast the accumulation of the waves produces high tides in the Bay of Bengal and the Arabian Sea. The lower part proceeds rapidly toward the west, and, encountering the southern extremity of Africa, turns with increasing speed toward the northwest through the deep channels of the Atlantic Ocean. In about twelve hours it reaches the coast of North America, from which point it turns to the northeast, and with slackened speed sweeps around the coast of Europe and becomes lost in the Arctic Ocean.

In the North Pacific Ocean the general course of the wave, instead of being due west, is toward the northwest; in the equatorial portion of this ocean the speed of the wave is diminished by the numberless islands of Polynesia. The influence which shallow water and friction against the coast produce is clearly illustrated by the slow progress made by the tide between Australia and the island of Papua; the effect of deep water is also shown by the rapid motion north of the equator. Here, however, the tidal wave becomes so curved that, while one part moves toward the west and reaches the coast of Asia, another part turns north and east toward North America. South of the equator, while the main wave is moving nearly due west, a reflected wave moves to the east, producing the tides on the western coast of South America; at Cape Horn this wave meets the tides of the Atlantic moving from the east.

66. **Height of the Tides.**—The great tidal wave rises but 2 or 3 feet in mid-ocean; but when it strikes against the coasts of continents or enters bays with a wide opening, it often rises to a great altitude.

On the eastern coast of North America, which is exposed quite evenly to the Atlantic wave, the tide rises and falls from 1 to 10 feet at the projecting capes and peninsulas, which first feel the effect of its approach, while in the intermediate depressions of the coast the difference between high and low water is from 1 to 53 feet. In the Bay of Fundy, which is peculiarly exposed to the advance of the wave, the tide, which at the entrance is about 18 feet high, rushes with great force up the bay, and is 53 feet at the head, occasionally reaching the extraordinary height of 60 or even 70 feet.

Wherever the advancing wave enters the wide mouth of a V-shaped bay the tides are usually high, and, on the contrary, large bodies of water having narrow and shallow entrances are practically separated from the tidal wave and its effects. In the Mediterranean the tides are, except at a few points, small and inconspicuous. In the Gulf of Mexico there is only a very small tide, and at many points on its coast only one tide a day is observable.

67. The difference in the heights of the tides at places along the same coast is evidently due to the shape of the shore. A cape or an island may divide the tidal wave in such a manner that on its opposite sides the tides may rise to different heights. Should the two bodies of water thus affected be connected by a narrow channel, a conflict of currents each having a different level may ensue; instances of tidal opposition of this kind are not uncommon.

By consulting the chart, it will be seen that the tidal wave of the North Atlantic, after sweeping along the western coast of the British Isles, bends around the northern part of Scotland and moves southward through the North Sea. At the same time a portion of the wave, following its original direction toward the northeast, passes to the south of England and encounters the tide of the North Sea in the English Channel and the Strait of Dover, producing the disturbed condition of the water for which both are noted.

The commotion at Hell Gate in the East River, New York, is due to strong tidal currents flowing among reefs in the crooked channel between New York Bay and Long Island Sound. To similar causes may be attributed the dangerous whirlpools which have been celebrated on various coasts. The famous Maelstrom, off the Norwegian coast, is but a whirling motion of the tidal current as it rushes with great violence between two of the Lofoden Islands Scylla and Charybdis, so much dreaded by ancient navigators, are whirlpools caused by conflicting tide-currents in the Straits of Messina.

68. The **Length of the Flood-Tides and Ebb-Tides** would be equal if no obstacle interfered with the progress of the tidal wave. In bays and gulfs, where the height and velocity of the wave are increased, the time of the flood-tide is less than six hours, while the duration of the ebb-tide is proportionately increased.

The difference in the duration of flood- and ebb-tide is still more exaggerated in the estuaries of large rivers, where the struggle between the outflowing current of the stream and the ascending tide produces a great wave, which, like a moving wall of water, rushes up the river with great rapidity, accompanied by a roaring noise. Such waves—which are called **Bores**—often ascend the stream for hundreds of miles and then suddenly subside. This rapid rising of the tide frequently occupies but a few moments.

In the Hoogly River, in the Ganges Delta, the bore advances up the stream with great velocity; in the Tsien-Tang, in China, the wave is often 30 feet high, and travels at the rate of 25 miles an hour. At some seasons several such bores follow one another up the Amazon in quick succession.

69. **Inequalities between the Two Daily Tides** are observed in some localities. These inequalities, which are manifested sometimes in the height and sometimes in the duration of the tides, are caused in part by the inclination of the earth's axis to the orbit of the moon.

On the northern coast of Australia a difference of 4 feet is sometimes observed between the morning and evening tides. Variations are also observed on the Pacific coast of North America and in the Gulf of Mexico, and instances are recorded where an expected tide has failed to appear.

Questions.—By what is the ocean moved? What is wave-motion? What is the ordinary height of waves? What is the breadth? The velocity? How do wind-waves differ from tidal and earthquake waves? What are breakers? Upon what does their force depend? What are breakwaters? What is the ground-swell? What are tides? By what are they caused? What are spring-tides? Neap-tides? When do the highest tides occur? What effect have the continents on the progress of the tides? Are extensive tides produced in small basins? What is a cotidal chart? Describe the progress of the tides. What is the usual height of the tide? How do the entrances to bays affect the height? How are tidal currents caused? What are bores? Are the daily tides always equal?

VII. Oceanic Currents.

70. **Oceanic Currents** are vast streams in the sea flowing in some given direction. Within the tropics they transfer the water from side to side of the oceanic basins, and between the continents they move it back and forth between the Torrid and Frigid Zones in perpetual circulation.

These streams usually differ in their temperature and in their color from the stiller water on either side. Their edges are sometimes sharply defined, but more often their current mingles and gradually blends with the adjacent waters.

These great streams are not to be confounded with the minor and more local and temporary currents which are common along the coasts and in harbors. These latter are sometimes produced by gales, but more often by the tides passing through narrow channels or among rocks and islands, as described in paragraph 67.

71. **Several Causes** acting together produce the oceanic currents. Of these, the wind is an important factor. A strong wind by its friction and waves drags the surface of the water along with it. This is well shown in long lakes, where a strong wind blowing lengthwise of the lake will raise the water at one end and depress it at the other. The trade-winds cause broad surface-currents to flow westward across the ocean between the tropics.

These waters, warmed by the tropical sun, expand and become relatively lighter than the colder waters on either side. This also tends to create movement and circulation, which always occur in waters unequally heated.

Rapid evaporation in some parts of the ocean while rain is falling on other portions, the melting of ice in the polar regions, and the influx of great rivers change the saltness of parts of the sea, and thus disturb the equilibrium of its waters.

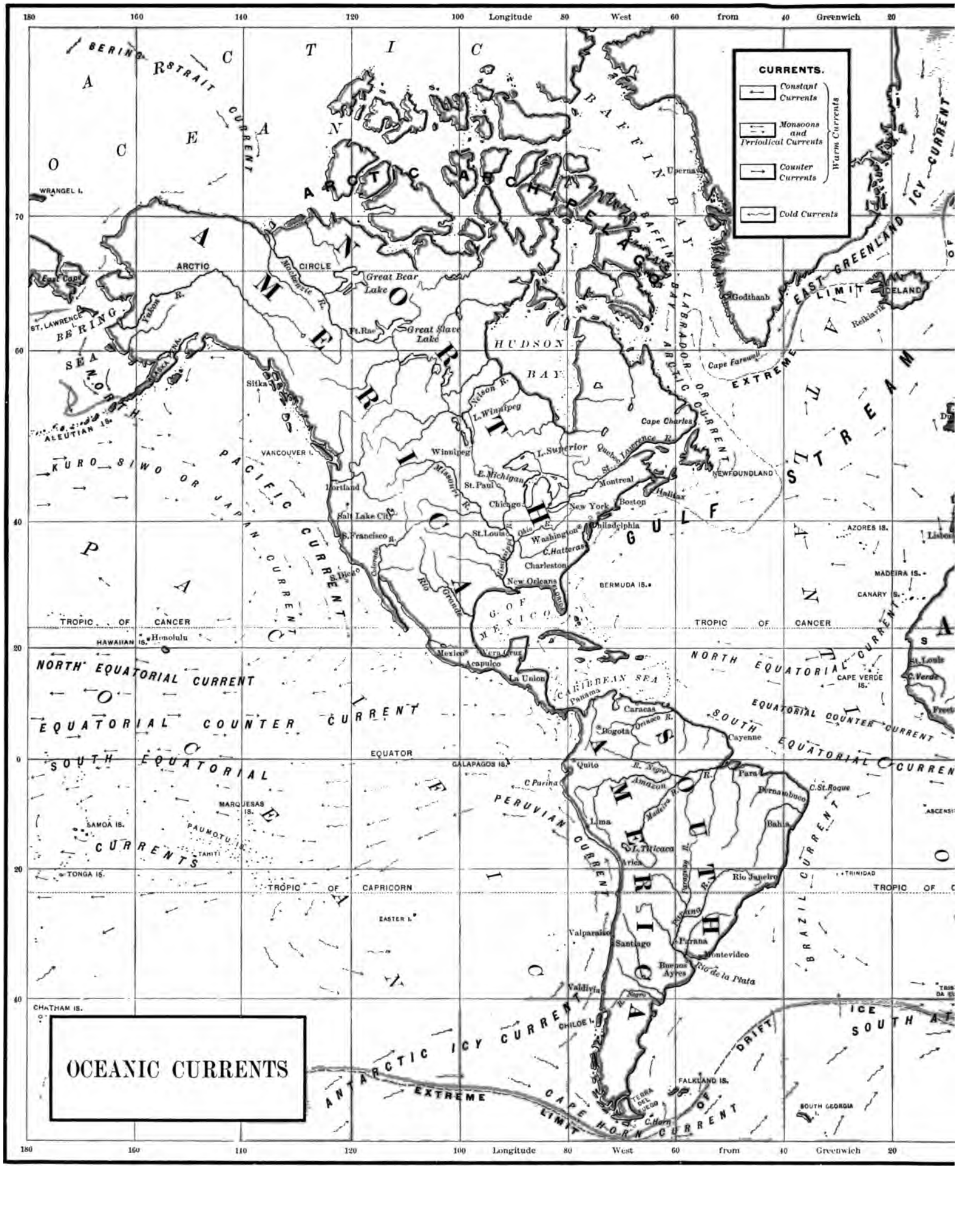
The motion of the earth on its axis is another cause which is instrumental not only in producing currents, but also in giving them their direction. At the equator the surface of the revolving earth moves eastward at the rate of 1037 miles per hour, or more than 17 miles per minute. At the latitude of 60° the motion is but half as great, and at the poles it is nothing. The seasons also exert an influence on the currents.

All these different causes acting together change the level of the sea and set it in motion. The water in the Gulf of Mexico at the mouth of the Mississippi is heaped up 40 inches higher than the water in the Atlantic at the mouth of New York Harbor.

Under the influence of these various causes, the sea is in perpetual movement. Currents are mingling the waters of all the oceans, equalizing their temperatures and their saltness, and modifying the climates of their shores.

Scientists are not agreed among themselves as to how great the relative value of each of these influences is in the formation of currents, and as a consequence there are several theories. Owing to its importance to navigation, as well as to the great interest of the subject itself, much study has been devoted, in recent years, to oceanic circulation.

72. **The General System of Oceanic Currents.**—There are three great systems of oceanic currents. In the first place, there is a general westward movement of the surface-waters between the tropics and under the trade-winds. There are several currents—not very sharply defined, but known generally as the **Equatorial Currents.** They are stronger a little north and a little south of the equator than on the line itself, and fluctuate somewhat in position with the seasons.


OCEANIC CURRENTS
CURRENTS.
Constant Currents
Monsoons and Periodical Currents
Counter Currents
Warm Currents
Cold Currents
Longitude West from Greenwich
ARCTIC OCEAN
BERING STRAIT CURRENT
ARCTIC ARCHIPELAGO
BAFFIN BAY
NORTH AMERICA
SOUTH AMERICA
HUDSON BAY
LABRADOR OR ARCTIC CURRENT
EAST GREENLAND ICY CURRENT
EXTREME LIMIT
GULF STREAM
ATLANTIC OCEAN
PACIFIC OCEAN
KURO SIWO OR JAPAN CURRENT
PACIFIC CURRENT
NORTH EQUATORIAL CURRENT
EQUATORIAL COUNTER CURRENT
SOUTH EQUATORIAL CURRENTS
PERUVIAN CURRENT
BRAZIL CURRENT
ANTARCTIC ICY CURRENT
CAPE HORN CURRENT
SOUTH ATLANTIC DRIFT
ARCTIC CIRCLE
TROPIC OF CANCER
EQUATOR
TROPIC OF CAPRICORN
G. OF MEXICO
CARIBBEAN SEA


20 Longitude 40 East 60 from 80 Greenwich 100 120 140 160 180
70
60
40
20
0
20
40
ARCTIC CURRENT
SPITZBERGEN
NOVAYA ZEMLA
KARA SEA
North-East Cape
ARCTIC OCEAN
EAST GREENLAND CURRENT
ISLANDS OF NEW SIBERIA
Sagastyr
Lena R.
Werchoyansk
ARCTIC CIRCLE
Kolimak
Kolima R.
Hammerfest
North Cape
L.Enara
Kola
Haparanda
White Sea
Archangel
Dwina R.
L.Onega
L.Ladoga
BALTIC SEA
St.Petersburg
Moscow
Konigsberg
Berlin
Vienna
Odessa
Danube R.
Constantinople
BLACK SEA
Smyrna
MEDITERRANEAN SEA
Beyrut
Jerusalem
Barca
Cairo
Suez
Nile R.
RED SEA
Mecca
Bushire
Persian Gulf
Karachi
Indus R.
Delhi
Muscat
Aden
Khartoom
Lake Tchad
C.Guardafui
Gondokoro
Victoria Nyanza
Lake Tanganyika
Ujiji
Banana
Loanda
Congo R.
Lake Nyassa
Zambezi R.
Tete
Mossamedes
Sofala
Orange R.
Port Natal
Cape Town
Tobolsk
Obdorsk
Ob R.
Yenisei R.
Turushansk
L.Tonguska R.
Yeniseisk
Tomsk
Omsk
Irkootsk
L.Baikal
Lena R.
Yakootsk
Okhotsk
OKHOTSK SEA
KAMCHATKA
Petropaulovski
Amoor R.
Kiakhta
SAGHALIN I.
KURILE Is.
Tiflis
Ural R.
Volga R.
Astrakhan
CASPIAN SEA
Aral Sea
L.Balkash
Kuldja
Khiva
DESERT OF GOBI
Vladivostok
Peking
Yarkand
Herat
Teheran
Cabul
Hoang Ho R.
JAPAN SEA
COREA
YELLOW SEA
Yang-tse-Kiang R.
Shanghai
Tokio
Lassa
Brahmapootra R.
Ganges R.
Calcutta
Bombay
Madras
CEYLON
Canton
HAINAN
FORMOSA I.
TROPIC OF CANCER
LUZON
Manila
Bangkok
Menam R.
Saigon
Singapore
CHINA SEA
MINDANAO
BORNEO
SUMATRA
JAVA SEA
CAROLINE Is.
NORTH EQUATORIAL CURRENT
EQUATORIAL COUNTER CURRENT
EQUATOR
NEW GUINEA
SOLOMON Is.
Banca I.
Port Darwin
ARAFURA SEA
CORAL SEA
VITI Is.
NEW CALEDONIA
ARABIAN SEA
SOCOTORA I.
BAY OF BENGAL
INDIAN OCEAN
EQUATORIAL COUNTER CURRENT
SOUTH EQUATORIAL CURRENT
MONSOONS
MADAGASCAR
REUNION
MAURITIUS
TROPIC OF CAPRICORN
CENTRAL AUSTRALIA DESERT
Perth
Adelaide
Melbourne
Sidney
Brisbane
L.Eyre
Darling R.
Murray R.
AUSTRALIAN CURRENT
TASMANIA
EAST
Auckland
NEW ZEALAND
Otago
AUCKLAND I.
PACIFIC OCEAN
WEST AUSTRALIAN CURRENT
ANTARCTIC ICY CURRENT
ICE DRIFT
RETROGRADE CURRENT
SOUTHERN CAPE CURRENT
CAPE CURRENT
EXTREME LIMIT OF
PRINCE EDWARD Is.
KERGUELEN I.
ST.PAUL I.

When these currents meet the continents, they are turned both ways along the western sides of the oceans toward the poles. They are streams of warm water in the cooler waters of the middle latitudes, and are called the **Return Currents.**

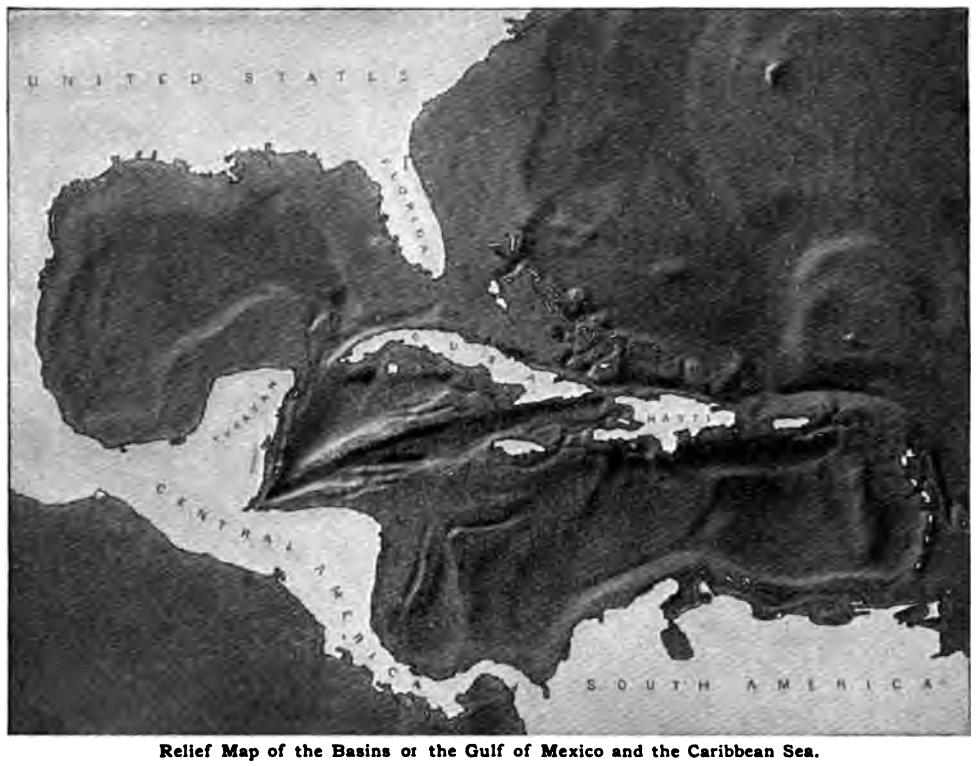
As they pass toward the higher latitudes they are constantly coming to regions where the hourly rate of motion of the earth on its axis is less and less, and between 40° and 60° of latitude it is so much less that the momentum acquired in the tropical regions deflects the water—or, at least, a part of it—diagonally across the ocean again to the eastward.

The constant flow of these warm waters to colder regions, where they are cooled, makes necessary the third system of currents to restore the equilibrium. This is done by streams of cold water called **Polar Currents** flowing from the polar regions toward the equator.

As cold water is relatively heavier than warm water, it often happens that a warm current flows in one direction over a cold current flowing in another direction. Moreover, the deep sea is everywhere cold at the bottom.

These three sets of currents produce in the oceanic basins a circulation on a stupendous scale, far exceeding in magnitude the circulation in the rivers and lakes on the continents.

The map (pages 60 and 61) shows that in the three oceans the main circulation is in a vast circle or ellipse on either side of the equator, with branches extending into the polar regions.



Relief Map of the Basins of the Gulf of Mexico and the Caribbean Sea.

73. The **Currents of the Atlantic Ocean** are better defined and better known than those of other oceans.

One portion of the equatorial current deflects southward and makes the Brazilian current, which sends a branch eastward toward the Cape of Good Hope, where it turns and rejoins the equatorial current. Another, and greater, portion is turned northward. A part enters the Caribbean Sea and Gulf of Mexico, where it is further warmed. A part flows against and among the West India Islands. Near Florida these gather into the Gulf Stream, which flows northward, and which is the most wonderful of all the oceanic currents.

The polar current of the Atlantic comes down along the coast of Greenland and Labrador. A portion passes under the Gulf Stream, and a portion flows between the Gulf Stream and the land. The green cold water modifies the climate of the eastern coast of the United States. Another stream of cold water comes down between Greenland and Iceland.

The Gulf Stream is the most interesting, as well as the best known, of all the ocean currents. Its limits are more sharply defined, its current is swifter, it is crossed by more ships and has been more thoroughly studied, than any other current. Part of its waters *come from* the Gulf of Mexico, but more from the Caribbean Sea without entering the Gulf. Another but smaller portion comes up along the northern coast of Cuba.

The configuration of the bottom of the Caribbean Sea and the Gulf of Mexico has much to do with the character and formation of the Gulf Stream, and the accompanying relief map, constructed from data supplied by the extensive investigations of the United States Coast Survey, furnishes a very accurate idea of the area covered by the water of these important arms of the Atlantic.

It will be seen that both, as compared with the bed of the ocean itself, are shallow basins. An extensive depression near the center of the Gulf and two smaller spots are a little over 2 miles below the surface, but a great part of its area is covered by water not over 600 feet deep, while a very considerable portion has a depth not exceeding 60 feet.

In the Caribbean Sea there are two deep basins, the more western measuring about 3 miles. The deepest points of both bodies of water, however, lie below the general level of a submerged plateau which is but an extension of the continents of North and South America. Were the level of the Atlantic Ocean to be lowered a mile, this plateau would become dry land, containing two lakes in the central part of the basins now occupied by the Gulf of Mexico and the Caribbean Sea.

A very large portion of the surface-water of the Atlantic north of the equator tends toward these basins. The great equatorial current, urged westward by the trade-winds, impinges upon the coasts of South America and the Antilles, and forces its way into the Caribbean Sea. Commander Bartlett believes that it circulates throughout the entire basin, where, after becoming still further heated, a portion of the current, still driven by the trade-winds, enters the Gulf of Mexico through the Yucatan Channel. The section of this passage is, however, too small to allow an outflow equal to the inflow from the east, and the greater part of the current therefore finds its way through the straits between the islands which form the northern boundary of the sea; and this constitutes the larger part of the Gulf Stream.

The outlet of the Gulf of Mexico through the Strait of Florida is also less capacious than the Yucatan Channel, and, as the Gulf furnishes no western egress for the current, its own waters are heaped up above the level of the sea. This remarkable example of unstable equilibrium, which for a long time was disputed by many able scientists, has now been proved and the amount of accumulation has been definitely measured by officers of the United States Coast Survey.

The Gulf of Mexico, on account of its shallow basin, becomes, like the Caribbean Sea, very warm, its temperature reaching 86° in September and October. It thus acts as a great accumulator of heat and a vast hydrostatic reservoir to add to the efficiency of the Gulf Stream, which emerges through the Straits of Bemini as an immense body of superheated water, and parts with both its heat and its velocity on its journey to the north.

At the Strait of Florida it is about 40 miles wide and 3000 feet deep, with a surface-velocity at the swiftest point of 6 English miles per hour. From this point it widens, grows shallower, and the current becomes slower. Off Cape Hatteras it is about 75 miles wide: and when it reaches the Banks of Newfoundland, it is over 300 miles wide and its current has slackened to a little over a mile per hour.

Its temperature at the Strait of Florida is about 80°, and, as it parts with its heat during its course, it modifies the climates of various countries.

The vast amount of heat conveyed from the tropics to the northern regions by the Gulf Stream can scarcely be realized. Could its heat be concentrated at a single point, it would be sufficient continually to melt enough iron to produce a stream of liquid metal as large as the Mississippi.

Through much of its course the bed of the Gulf Stream is formed by the colder water of the ocean. This fact is of the utmost importance. Water, with its great capacity for heat, is a very poor conductor. A piece of metal heated at the top will soon become warm at the bottom; but motionless water, when heated at the surface, will not convey the heat downward, and even when the water is in motion the heat is transferred very slowly. Consequently, the cold bed of the Gulf Stream allows it to pass on stored with the heat which is ultimately given to the air in the higher latitudes.

Off the coast of the United States, to above Cape Hatteras, the waters of this stream are of an intense indigo-blue, in beautiful contrast with the green and colder adjacent waters. Its edges are so sharply defined that in places a ship entering it may have its bows in the warm blue stream, while the other end of the vessel may be in the green waters of the outer ocean.

Off Newfoundland a branch turns northward over the cold polar current, and flows toward the Arctic Ocean by way of Greenland; but the main stream deflects eastward across the Atlantic.

One branch of the main stream goes northward past the coast of Norway and North Cape, and is lost in the Arctic Ocean. Mahogany and other woods from Central America are cast up on the shores of Lapland, and fruits from the same region have been found as far away as Siberia.

Another branch curves southward along the western coast of Europe and Africa, and finally joins the equatorial current in its ceaseless cycle. It is believed that an object floating within this current would make the round in less than two years. The volume of water is a thousand times greater than that of the Mississippi or the Amazon.

74. **The Currents of the Pacific Ocean.**—The general circulation of the Pacific Ocean is very much like that of the Atlantic, but it is modified by the islands and coasts.

The currents south of the equator are much disturbed and broken by the numerous islands in their way. North of the equator the ocean is much more regular, and gives origin to a current off the east coast of Japan analogous to the Gulf Stream. It is called the Kuro Siwo ("Black Water"), from its dark-blue color.

The Kuro Siwo is not so sharply defined nor so swift as the Gulf Stream, but resembles it in many particulars. But little—if, indeed, any—of it passes into the Arctic Ocean, but it crosses the Pacific and modifies the climate of Western North America from Alaska to Oregon.

A small polar current passes through Bering Strait into the Pacific.

75. **Currents in the Indian Ocean.**—South of the equator the currents are believed to be rather regular. The Indian Ocean is so continuous with the Antarctic that the polar currents are very simple, but those regions are so little navigated that we lack satisfactory observations on the actual currents.

North of the equator the surface-currents are governed by the monsoons, or periodical winds, and flow back and forth, according to the season.

76. **Grassy Seas.**—The three systems of currents enclose vast oval-shaped regions with comparatively quiet water. Here enormous masses of sea-weed collect and grow, from which these oval regions receive the name of *grassy seas*.

If a vessel containing pieces of straw, shavings, or other light substances, be partially filled with water, and the water be so stirred as to impart to it a circular movement, the floating substances will collect near the center of the vessel, where the motion is least. This circular movement corresponds to the elliptical movement of the oceanic currents, and the grassy seas have a similar origin.

The grassy sea between the Gulf Stream and the equatorial current is so thickly matted over with sea-weed that the progress of vessels passing through it is often retarded. Columbus saw this grassy sea—called by the Spaniards the Sargasso Sea—in his first voyage of discovery; and as he saw it, so it is to-day.

77. **Influence of the Currents.**—The great work performed by the currents is so varied and so wonderful that it is difficult to comprehend. Were it not for the agency of the ocean and the air in regulating climate, the earth, so carefully prepared in other respects for the sustenance of life, would become nearly—if not quite—uninhabitable. Without these constantly circulating currents, the geology and history of the globe would not be what they are.

This grand systematic movement of the waters may be compared to the circulation of the blood in the bodies of animals. As every part of the body is nourished by the warmth and the food carried to it by the blood, so the waters of the ocean convey the heat and the moisture which sustain all forms of terrestrial life.

More heat is carried to the Arctic regions by the Gulf Stream than reaches them from the sun. Without the influence of this current many of the civilized portions of Europe would be unfit for habitation. The British Isles now enjoy a climate similar to that of New York and Philadelphia, though lying as far north as Labrador, and the temperature of the Norwegian coast is higher than that of Eastern North America 1000 miles farther south. The climate of Alaska and the Pacific coast of North America is, in like manner, tempered by the Kuro Siwo.

Were it not for this transportation of heat from the tropical regions toward the poles, and the return of cold water and cold air from the polar seas, the countries near the equator would be so hot that man could not live in them. Following the western coast of South America from south to north flows a great cold stream from the Antarctic which lowers to a remarkable degree the temperature of all the countries whose shores it bathes; without its refreshing influence the climate of Peru would be very different from that which now exists there.

In the great work of building up the rocks which has taken place at the bottom of the sea, the ocean currents have always been active agents. The mud and the sand brought by the rivers and the material washed out by the tides are carried and deposited by these oceanic streams over the submarine bed.

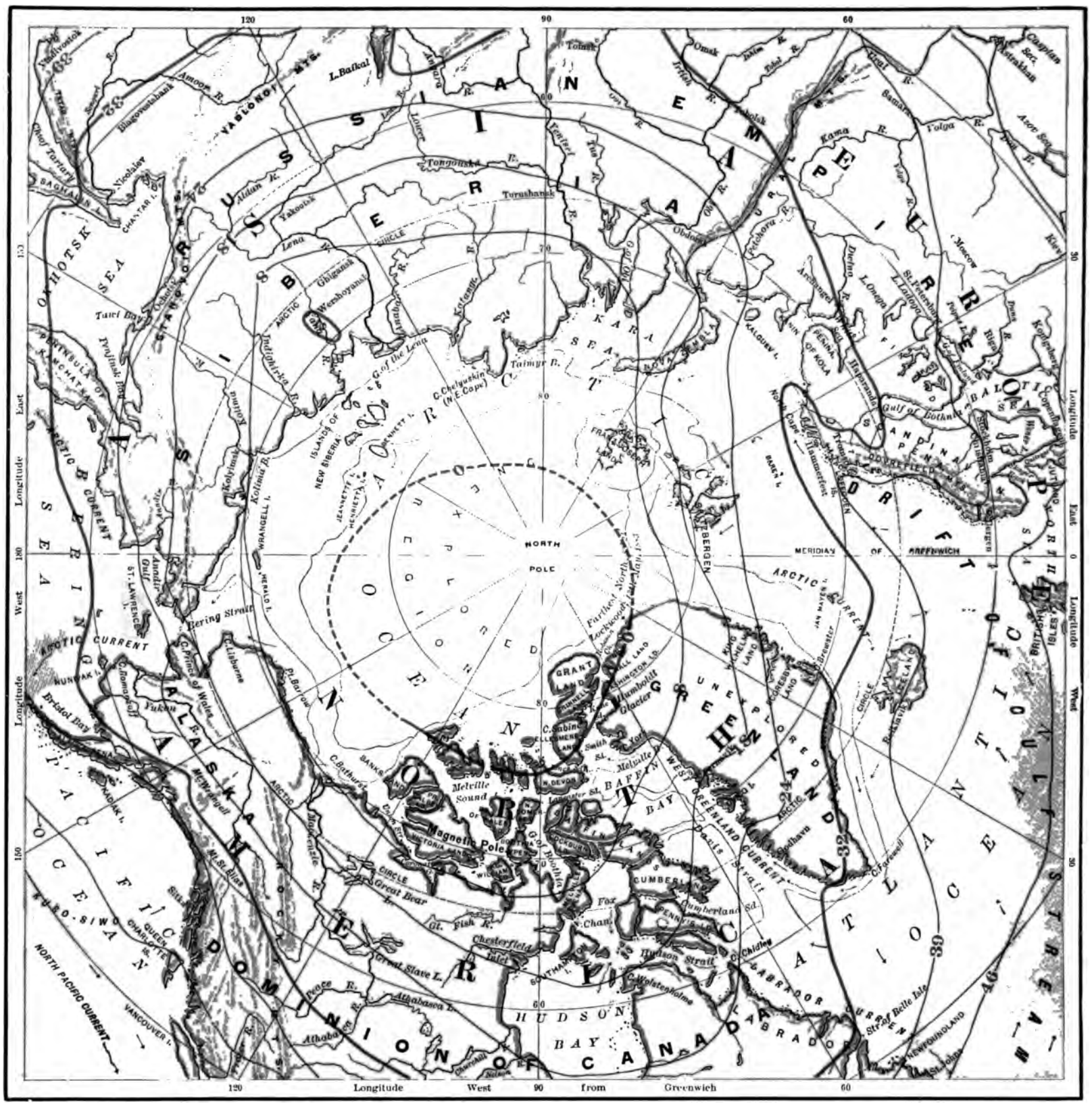
The cold currents coming toward the equator from the poles are at certain seasons laden with icebergs, which frequently contain masses of rock torn from the frigid shores or brought up from the shallow bottom of the polar seas. When these cold currents encounter a warm stream, the ice is melted and a deposit occurs. The Banks of Newfoundland are the result of such an accumulation, which has been increasing for ages where the Labrador current meets the Gulf Stream, and it is but the foundation of an embryo continent which may some day reach the surface.

The upheavals and the sinking of the land in geological ages probably made the courses of the currents somewhat different from those followed at present, and the conditions of climate which then existed, and which were so at variance with those of the present age, are thus explained by some geologists. It is well known that mammoth elephants and other large animals, as well as various forms of plant-life like those now found in mild climates, once flourished in North America and Siberia even north of the Arctic Circle.

These countries enclose an ocean almost completely cut off from the Pacific, and one which receives only the waste heat of the Gulf Stream; but let the Aleutian Islands sink deep below the surface, and let Bering Strait become a wide channel, and the inflowing Kuro Siwo, relieved of the barrier which forces it to the south, might possibly restore to these northern regions a climate like that which they enjoyed in the Tertiary Age.

The influence of the currents in shaping the history of mankind is scarcely less interesting than their climatic and geological effects.

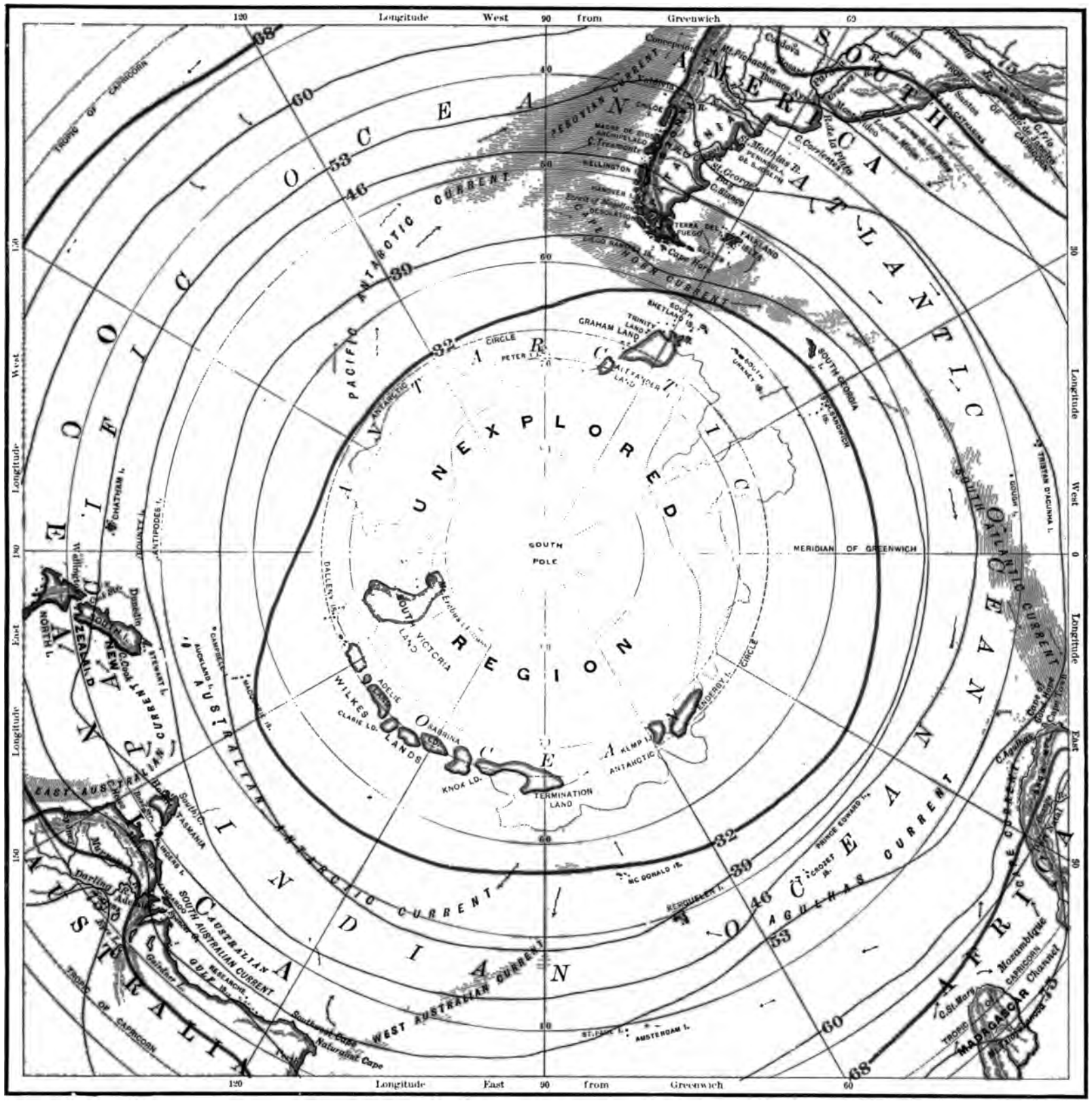
Without the aid of the north equatorial current and the trade-winds, it is doubtful whether Columbus would have discovered the New World; and had it



not been for the Gulf Stream, he might not have returned to announce his success. His faith in the existence of a Western Continent was possibly strengthened by an acquaintance with the earlier discoveries of the Norsemen, who appear to have been carried, either purposely or unintentionally, as far south as Narragansett Bay, by the Arctic current which skirts along the eastern coast of North America.

Numberless traditions relate how Japanese sailors have drifted on the bosom of the Kuro Siwo to the western shores of North America, and many scholars believe that the country of Fusang mentioned in the annals of China was none other than Mexico and Central America, which Chinese navigators discovered more than ten centuries before Cortez invaded the empire of Montezuma.

78. The **Polar Regions** receive some of the drift of the warm currents. In this respect the Arctic region is more favored than the Antarctic, as may be seen by examining the maps; in these frigid zones the cold currents have their origin, and flow toward the equator. Over one-third of the area included within the Arctic Circle is yet unexplored, and a still greater extent around the south pole has never been visited by man. Actual observation in these regions has been very limited, and definite knowledge of the polar currents is therefore scanty, and, in a great measure, hypothetical.



ANTARCTIC REGIONS

Around either pole there extends a frozen ring which practically stops navigation. There are reasons for believing that these rings do not continue with increasing thickness to the poles, and the experiences of Kane and other explorers seem to furnish some evidence that within the belt formed by the ice-fields, ice-floes, and bank-ice there exists an open polar sea.

The red lines on the maps indicate the mean annual temperature, and reference will be made to them later on. These vast frozen zones undoubtedly play an important part in the physical economy of the globe. The formation of such an immense quantity of ice, which at certain seasons melts or is carried by the currents to lower latitudes, modifies both the temperature and the saltness of the sea.

Questions.—What are ocean currents? What are some of the principal causes which produce them? Where are the equatorial currents? What are the return currents? In what direction do the polar currents flow? What is the form of the main circulation? In what ocean are the currents best known? What current flows from the equator toward the south? Toward the north? What currents come from the vicinity of the north pole? In what bodies of water does the Gulf Stream have its origin? How is the water of the Atlantic forced into these basins? Describe the character of their beds. What change of level is produced? What is the effect of the temperature on this current? Describe its course. What is said of its heat? What is the principal current of the Pacific? What is the nature of the currents in the Indian Ocean? What are grassy seas? What are some of the climatic effects of the currents? What connection have the currents with geology? With history? What is said of the polar regions?

REVIEW AND MAP QUESTIONS.

At what temperature does fresh water freeze? At what temperature does it boil? What is ground-water? What constitutes the difference between a spring and a swamp? How do springs vary in the quantity of water discharged? In the flow of water? In temperature?

What is the distinction between fresh water and salt water? What is alkaline water? Bitter water? Sulphur water? Chalybeate water? What is a soda spring?

What is the source of a stream? How is a great river formed? What is a basin or drainage-area? How is one river-basin separated from another? Is the amount of water discharged by different rivers always proportionate to the extent of the basins? What other causes regulate the quantity of water? What determines the length of a river? What ocean surpasses all others in the amount of drainage received?

What is considered a moderate velocity for the flow of a river? Is the velocity of a river uniform throughout its course? In what part of a river is the speed likely to be the greatest? Why? How are rapids and falls produced? What kind of a river-bed is necessary for their formation? What condition of the bed is essential to the existence of cataracts? What effect has muddy water upon the production of cataracts?

Is the height of the water in a river uniform at all seasons? If not, to what is the lack of uniformity due? Do the changes in height ever assume a periodical character? Where? How is the overflow of the Nile explained?

In what part of a river-system is erosion most perceptible? Does it affect the whole drainage-area? How? Where are cañons most numerous and remarkable? What becomes of the material eroded by a river? How is transportation regulated? How does the character of the water in outlets of lakes differ from that of rivers receiving the immediate drainage of their basins? What effect is produced by the mingling of river water with salt water? What are the peculiar features of the different courses of any river?

Is the course of a river usually in a direct line from its source to its mouth? Do large rivers always discharge their waters through a single mouth? Do they always form deltas? What are some of the important characteristics of deltas? What difficult problems arise from the nature of deltas? What name is given to a very expanded river-mouth?

Does the entire amount of rain and snow which fall upon the land flow to the ocean in rivers? What are interior basins? Which is the longest river on the globe? The largest river?

Into what two general classes are lakes divided? Which class contains the greater number of lakes? Where is the most extensive lake-region of the earth? Name the deepest lake in North America. Where are the lake-regions of Europe? What lakes in Asia are below the sea-level? Where is the lake-region of Africa?

How does the character of the sea-bottom compare with the surface of the land? Where is the greatest variation in temperature in the ocean, at the surface or in the deep waters? Which is the largest of the arbitrary divisions of the ocean? The smallest?

What is the cause of ordinary waves? By what other causes are waves produced? Describe the influence of the moon in producing tides. Why are there two daily tides? Why do the height and the velocity of tidal waves vary in different places? What are some of the causes which produce differences in the length of flood- and ebb-tides?

How is the water of the ocean kept in circulation? What are the three great systems of ocean-currents? Which is the best known of the currents? What effect has the character of the beds of the Gulf of Mexico and the Caribbean Sea on the formation of the Gulf Stream? Name some of the important influences of ocean-currents.

(*In answering the following questions consult the maps, pages 50–51, 60–61, and 64–65.*) Into what ocean are the waters of the Great Lakes of North America discharged? What ocean ultimately receives the waters of Victoria Nyanza? Great Slave Lake? Into what ocean does Lake Nyassa empty its waters? Lake Baikal? Lake Ladoga?

What forms the great divide of North America? What forms the divide between the Atlantic and Arctic slopes? Into what body of water does the Mississippi flow? What is the extent of its basin? Name the three most important rivers on the Pacific slope of North America. What large river in North America flows into the Arctic Ocean?

Into what ocean do the large rivers of South America empty their waters? What constitutes the main divide of that continent? Why are there no large rivers on the Pacific coast? What two great river-systems of South America are connected by a navigable channel? What river flows into the Caribbean Sea?

Name some of the European rivers which flow into the Atlantic Ocean. Into the Arctic Ocean. What large river of Europe does not communicate with the ocean? What is the main divide of Europe? Is there any other divide? What rivers flow into the Black Sea?

What is the main divide of Asia? What forms the secondary divide? Name some of the rivers of Asia whose waters are received by the Arctic Ocean. What large river flows into the Okhotsk Sea? What rivers flow into the Yellow Sea? The China Sea? Bay of Bengal? What body of water receives the Tigris and Euphrates?

Which ocean receives directly or indirectly the greater part of the drainage of Africa? What African rivers flow into the Indian Ocean? Where is the main divide of Australia? Where is the most important river of that continent?

What sections of North America have no outlet to the sea? How do some of these basins vary in altitude? What regions in South America have only an interior drainage? Where is the largest area of interior drainage in the world? What are its dimensions? What large bodies of water occupy its western portion? What large rivers flow into them? What is the height of this part of the basin? How does it compare with the altitude of the eastern sections? In what peninsula of Asia are there areas without drainage to the sea? Where is the lowest portion of the earth's surface? What part of Australia is not drained into the sea?

Trace the course of the north equatorial current of the Atlantic Ocean. The course of the south equatorial current. Describe the course of the Gulf Stream and its various branches. Are these warm or cold currents?

What current flows from north to south along the eastern coast of North America? Is this current warm or cold? What current follows the coast of Greenland? In what direction? Is the Brazil current warm or cold? The Peruvian current? Of what current is the latter a continuation? What name is given to that branch which flows south of Cape Horn? Where is the South Atlantic current?

What is the character of the currents in the northern part of the Indian Ocean? Describe the south equatorial current of that ocean. What names does it receive, and what is its course after reaching the southern part of Africa? What cold currents in the vicinity of Australia and New Zealand?

Describe the Pacific north equatorial current. The south equatorial current. What is the course of the Kuro Siwo? Trace the northern limit of drift-ice in the Southern Hemisphere. The southern limit in the Northern Hemisphere. Around which pole is bank-ice most plentiful? Which region, the Arctic or the Antarctic, receives more of the drift from the warm currents? What are some of the probable effects of the great ice-caps found around both poles?

THE ATMOSPHERE.

I. Properties of the Atmosphere.

1. The **Atmosphere** is the entire outer gaseous envelope or mass of air which surrounds the earth. The term "atmosphere" is derived from two Greek words, *atmos*, "vapor," and *sphaira*, "sphere." In the economy of the globe the atmosphere is essential to the life of animals and plants; it retains and modifies the solar heat and carries moisture over the surface of the land, upon which it falls as rain or snow. Without the atmosphere the earth would be a barren and lifeless waste.

2. **Meteorology** is the science which treats of the atmosphere, its phenomena, and the laws which govern them. It comprises the following subjects: the properties of the atmosphere, temperature, winds, moisture, electrical and optical phenomena, and all other phenomena which together constitute weather and climate.

3. The atmospheric air is a mixture of gases of which the most important are oxygen and nitrogen. When the atmosphere is dry, it consists almost wholly of these two invisible gases combined in the proportion of about one part of oxygen and four parts of nitrogen. These proportions vary slightly at different times and in different places. In addition to these, there is a small amount of vapor of water which varies greatly at different times; a very hot, moist atmosphere may contain one-fiftieth of its weight of vapor, but taken as a whole the moisture does not amount to more than one one-hundredth part of the total atmosphere.

Oxygen is the most active chemical constituent of the atmosphere; it is a supporter of combustion and respiration, and in many ways produces important changes in the matter of the globe.

Carbonic acid, which constitutes only about one twenty-five-hundredth part of the atmosphere, is of little interest in Meteorology, although it is of great importance to the vegetable world. So, too, there are various other substances in still smaller proportion which play no part in phenomena of weather or climate, but which are of vast importance in the economy of life.

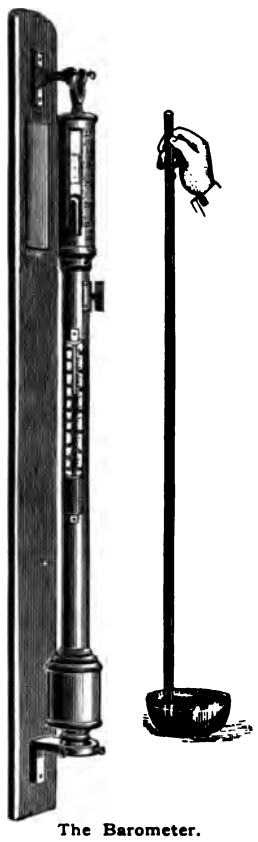
The gaseous components of the atmosphere are not in a state of chemical combination, but one of mixture merely; and although of different densities, from a peculiar law of gases called "diffusion," they maintain everywhere about the same relative proportions.

Several liquids having no chemical affinity for one another, when poured into the same vessel, will not remain mixed, but will separate and arrange themselves in the order of their specific gravities; the heaviest will settle to the bottom and the lightest will float upon the top. But if a number of different gases be admitted into a similar vessel, they will not arrange themselves in separate strata, like the liquids, but will penetrate one another, and after sufficient time has been allowed they will become so thoroughly mixed that the proportions of the various gases in the mixture will everywhere be the same. Were it not for this law of diffusion, the properties of the atmosphere would be greatly changed.

4. The air is very elastic—that is, it may be compressed, and it expands again when pressure is removed.

5. The air has weight. A cubic foot of dry air at 32° Fahr. weighs about 565 grains, which amounts to a little more than 2 pounds per cubic yard; because of this weight, it exerts a pressure upon the surface of the earth.

The pressure of the atmosphere is measured by the barometer devised by Torricelli, an Italian philosopher. The principle of its construction is best shown by his experiment. He took a glass tube about 3 feet long, open at one end, filled it entirely with mercury, and firmly closed it with his thumb. He then inverted it and placed the open end in a cup of mercury. Removing the thumb, he found that the mercury sank in the tube until the top stood about 30 inches above that in the cup. The mercury in the tube was sustained at that height by the pressure of the atmosphere on the surface of the fluid which was in the cup. This was at the sea-level. A column of mercury 30 inches high and 1 square inch at the base weighs nearly 15 pounds. It therefore follows that each square inch of the earth's surface at the sea-level bears that weight of atmospheric pressure.



The Barometer.

6. The pressure of the atmosphere at the sea-level is not, however, always uniform. It varies from day to day, and sometimes from hour to hour, and the average pressure is not the same at different places.

The difference of pressure of the atmosphere is shown on a map by connecting the adjacent places having equal pressure by a line. Such lines are called **Isobars.**

7. The lower strata of the atmosphere are denser and heavier than the upper strata, because they are compressed by the weight above.

About one-half of the total atmosphere is within 3½ miles of the surface of the sea, and nine-tenths of it within 12 miles.

The rate at which the pressure decreases with ascent into the atmosphere furnishes a ready means of obtaining the heights of mountains. Most of the mountains of the earth which have been measured at all have been measured by barometer. One barometer is observed at the base, and another observed at the same time at the top; the difference between the atmospheric pressures furnishes the chief data for calculating the height.

Breathing is quite difficult at the height of 3 miles, and any exertion is extremely fatiguing; only a very few of the most hardy mountaineers have climbed mountains to the height of 4 miles. The highest point ever reached by man in balloons, where no exertion is required, is about 7 miles.

8. The height of the atmosphere has not yet been ascertained. Its limit must be where gravity on the one hand and the force of repulsion on the other just balance each other.

It probably extends to the height of 500 or 600 miles, but the upper portions are so very thin that more than ninety-nine one-hundredths of it lies within 25 miles of the surface of the earth, less than one one-hundredth part of it lying above 25 miles.

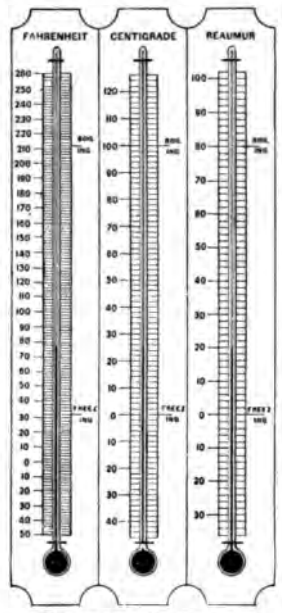
9. Heat expands the air and diminishes its density; cold contracts it, increasing its density. Moreover, it takes a smaller quantity of heat to raise a pound of air one degree of temperature than it does to warm equally a pound of either earth or water. Air is therefore more readily warmed than either earth or water, and also more readily cooled.

Questions.—What is the atmosphere? What part does it perform in the economy of the globe? What is meteorology? Of what does the atmosphere consist? What is the law of diffusion of gases? Is the air elastic? Can it be weighed? By what instrument is the pressure determined? Describe Torricelli's experiment. Is atmospheric pressure uniform? How is the variation of pressure shown on a map? How is the height of mountains determined? At what height will the atmosphere sustain life? What is the estimated height of the atmosphere? What is the effect of heat on the air?

II. Temperature.

10. The intensity of sensible heat which a body possesses is called its **Temperature.** It is measured by means of a thermometer, a simple instrument constructed on the principle that bodies expand with heat and contract with cold.

There are three kinds of thermometric scales employed in different parts of the world. Fahrenheit's, which is most generally used in the United States and other English-speaking countries, and which is taken as the standard in this work, has its freezing-point at 32° and its boiling-point at 212°; the Centigrade, which is used in France and usually in scientific works of other countries, has its zero at the freezing-point and its boiling-point at 100°; Reaumur's, in common use in Germany, has the two points respectively at zero and 80°. One degree of centigrade is equal to 1.8° Fahrenheit, and 1° Reaumur is equal to 2¼° Fahrenheit.



Thermometric Scales.

11. The sun is the source from which the earth's surface and the atmosphere receive heat. The heated internal part of the earth and the heat of the stars have too little influence on the surface to require any special notice here. There are, however, great differences between the relative absorption and retention of the solar heat by the land, the water, and the atmosphere.

12. The temperature of the surface of the land varies much more with the seasons than does that of the water; it is more readily heated by the direct rays of the sun, and cools more quickly by radiation. The surface of the land is therefore warmer in the summer and colder in the winter than that of the water.

The sun's heat warms the soil and the solid rock to only a very moderate depth. In descending into the earth a point is soon reached at which the temperature remains the same all the year round. In the Torrid Zone it is but a few feet below the surface; in the Temperate Zone it is from 40 to 75 feet. The temperature when this limit is reached is the same as the mean temperature of the climate of the place; below this point the crust of the earth grows continually warmer. (See page 11.) In the polar regions the earth is permanently frozen to a great depth, the surface thawing in the summer to but a slight extent.

The temperature of the soil at the surface rises to 140° or more in the hotter regions of the globe, and sinks to far below zero in the colder regions.

13. The ocean does not attain the same extremes of heat and cold as the solid land in the same latitude; but, owing to the law that surface-water sinks when cool, the line of invariable temperature is much lower in the ocean than on the land, and the water below this point is always cold.

The temperature of the surface of the water of the ocean sinks as low as 28°, or even 27°, in polar regions, and rises to above 85° in some places in the Torrid Zone. Surface-waters of the ocean within the tropics are, as a rule, warmer on the western sides of the ocean, while in the Temperate Zones the warmer waters are on the eastern sides.

14. The heat from the sun is received in three several ways:

(*a*) Most of that which enters the atmosphere by means of the sun's rays passes directly through to the earth. Only about one-fifth part is directly absorbed by the air.

(*b*) The larger part passes through the atmosphere (without directly warming it) to the surface of the earth, and is there absorbed. The earth, thus heated, warms the air which comes in contact with it. The lower regions are therefore warmer, while the higher layers become relatively colder in proportion to their elevation above the earth's surface.

(*c*) The warm earth also radiates heat back into the air, and this is absorbed by it even more readily than that which is radiated directly from the sun.

When the radiant solar heat falls on any substance, it may be either reflected, transmitted, or absorbed; only that portion which is absorbed becomes sensible heat and raises the temperature.

The temperature of the surface of the earth is due more to the absorptive power of the atmosphere, which acts as a blanket, than to the direct influence of the sun's rays. The greater part of the heat of the air is accumulated by slow radiation from the earth, but only enough is retained to keep the earth warm, while the excess escapes into space.

15. The **Average Temperature** of the air at a given place depends upon several circumstances, the chief of which are the latitude, the elevation above sea-level, the vicinity of the sea, oceanic currents, and prevailing winds.

16. **The Latitude.**—The earth absorbs the greater proportion of those rays of the sun which strike it vertically; hence it receives the greatest amount of heat in the tropics, while the polar regions, where the rays strike more obliquely, receive very much less.

17. **Elevation above the Sea-Level.**—The temperature of the atmosphere is greatest at the surface of the earth and at the sea-level, as has already been stated.

The rate of decrease as greater altitudes are reached varies with the latitude and with the state of the sky. The ratio of diminution is about one degree for each 350 to 500 feet of ascent. Hence, in ascending a high mountain in the tropics, a person passes through the same zones of climate as if he traveled from the equator toward the poles.

To a certain height above the sea, varying with the latitude, the snow that annually falls does not all melt during the summer. The lower limit of this region is called "the snow-line." It is highest within the tropics, and is at the sea-level in the polar regions.

The following are some of the observed heights of the snow-line in different parts of the globe:

	North Latitude.	Height in feet.
Spitzbergen	78°	1,000
Kamchatka	59½	5,249
Altai Mountains	50	7,034
Alps	46	8,885
Rocky Mountains	43	12,467
Mountains of Abyssinia	13	14,065
Andes Mountains	2¼	15,381
	South Latitude.	
Andes, near Quito	0°	15,820
Andes of Chili	42½	6,010
Magellan Strait	53½	3,707

The snow-line is not very definite, and depends upon the amount of snow which falls and on the dryness of the air, as well as on the elevation and the latitude.

18. **The Vicinity of the Sea.**—The ocean is warmer than the land in winter and cooler in summer.

An equal amount of exposure to the action of the sun's rays on a given area of land or water will not affect each to the same degree. The rays penetrate the water more thoroughly than they do the land, and from the motion of the water the heat is diffused through a greater depth. At the same time, more energy is required to heat a pound of water to a given point than to produce the same change in a pound of soil, and this energy reappears as sensible heat when the water cools. Consequently, the ocean both receives and parts with its heat more slowly than the land, and is, therefore, not subject to such sudden changes.

The land, on the contrary, is affected to only a moderate depth; it receives and throws off the sun's heat with greater facility, and is subject to rapid changes. Therefore, the difference between the summer and the winter temperature of the surface of the ocean is slight, while the temperature of the land may vary more than 120°.

The atmosphere over the sea, partaking of its temperature and borne by the winds to places on or near the coast, gives them a more uniform temperature than that which prevails at places distant from the sea.

The island of Madeira has a winter temperature of 61° and a summer temperature of only 70°. The average summer temperature of San Francisco is only about 9° higher than the average winter temperature. Yakootsk, in the interior of Siberia, on the other hand, has a winter temperature of 38° below zero and a summer temperature of 63° above, the difference being 101°. Madeira has what is known as a maritime and uniform climate; Yakootsk, a continental and excessive climate.

19. **Oceanic Currents and Prevailing Winds** greatly influence the temperature. Minnesota and Maine have about the same average temperature as Alaska and Norway. In each of these sections the prevailing winds are westerly, but in the latter countries the winds are tempered by the warm currents of the neighboring ocean. (See map of isothermal lines, and also map of oceanic currents.)

Figs grow in the open air near Paris and fuchsias grow throughout the year in the gardens on Vancouver's Island, while in our Eastern States, which are in the same latitude, only hardy plants can stand the cold winters. The harbors of New York and Boston are often obstructed with ice, while those on the west coast of Norway as far north as the Arctic Circle are always open.

20. **Mean Temperature** is the average temperature. If at any place the thermometer be observed at each hour of the day or at certain other specified times, the arithmetical mean of the observations thus made is the mean temperature of that place for the period over which the observations extend.

If at Boston, for example, the thermometer be observed each hour of the day and night, the sum of the degrees observed, divided by 24, is the mean temperature of that day. The mean yearly or annual temperature would, in a similar way, be derived from the sum of the daily mean temperatures.

The variation in mean annual temperature at any one place from year to year is very slight. Thus, the highest mean annual temperature at Geneva, Switzerland, for twenty years was 51.6°, the lowest during the same time was 49.9°, the difference being only 1.7°. At Paris for ten years the variations from the standard mean never exceeded it more than 3.4° or fell short of it more than 2.9°.

The variation in the abundance of the harvests is due more to differences in the distribution of heat and rain in the seasons of the year than to any difference in the actual annual supply of heat.

21. **Isothermal Lines.**—The mean annual temperature of many thousands of places all over the globe has been ascertained from actual observation extended over many years.

Lines connecting those places which have the same mean temperature are called *isotherms* or *isothermal lines*. If the mean be for the year, these lines are called *annual isotherms*. These lines, where they extend around the earth, are not parallel to the equator nor to one another, but form irregular curves.

22. **Zones.**—The zones into which the earth's surface is divided, as described on page 10, are bounded by the Tropics of Cancer and Capricorn and the polar circles. If the earth's surface consisted either entirely of land or entirely of water, and if there were not differences of elevation upon it, then the climatic zones would be bounded by the same lines. But as the temperature depends on a variety of causes, the zones of climate are bounded by isothermal lines.

The zone of climate which is essentially tropical lies between the isotherms of 68° on each side of the equator. The frigid climate extends from the isotherms of 32° to the poles. The temperate climate extends between the isotherms of 32° and 68°.

23. By examining the map, pages 70 and 71, the arrangement of the annual isotherms and their irregular character are apparent. The thermal equator, while lying approximately in the vicinity of the geometrical equator, is not a great circle, but a line contorted into numerous sinuosities, and so the lines of thermal latitude cross and recross the geometrical parallels.

One of the most important facts to be observed is the great difference between the sinuosities of the lines in the Northern and Southern hemispheres. This variation is even more strikingly shown on the polar maps, pages 64 and 65. Around the south pole and in the Antarctic Ocean, the isothermal lines are very nearly parallel to the degrees of latitude; the irregularity increases gradually with the approach to the equator.

In the Northern Hemisphere the irregularity is much more marked than in the Southern. There is no similarity in the arrangement of the isotherms and of the parallels of latitude around the north pole, and at other points north of the equator the lines of equal temperature cut the geometrical lines at all angles. Taken as a whole, the lines of the Northern Hemisphere form a double wave, the crests of which follow the western coasts of Europe and North America, while the greatest depressions are found along the eastern shores of North America and Asia.

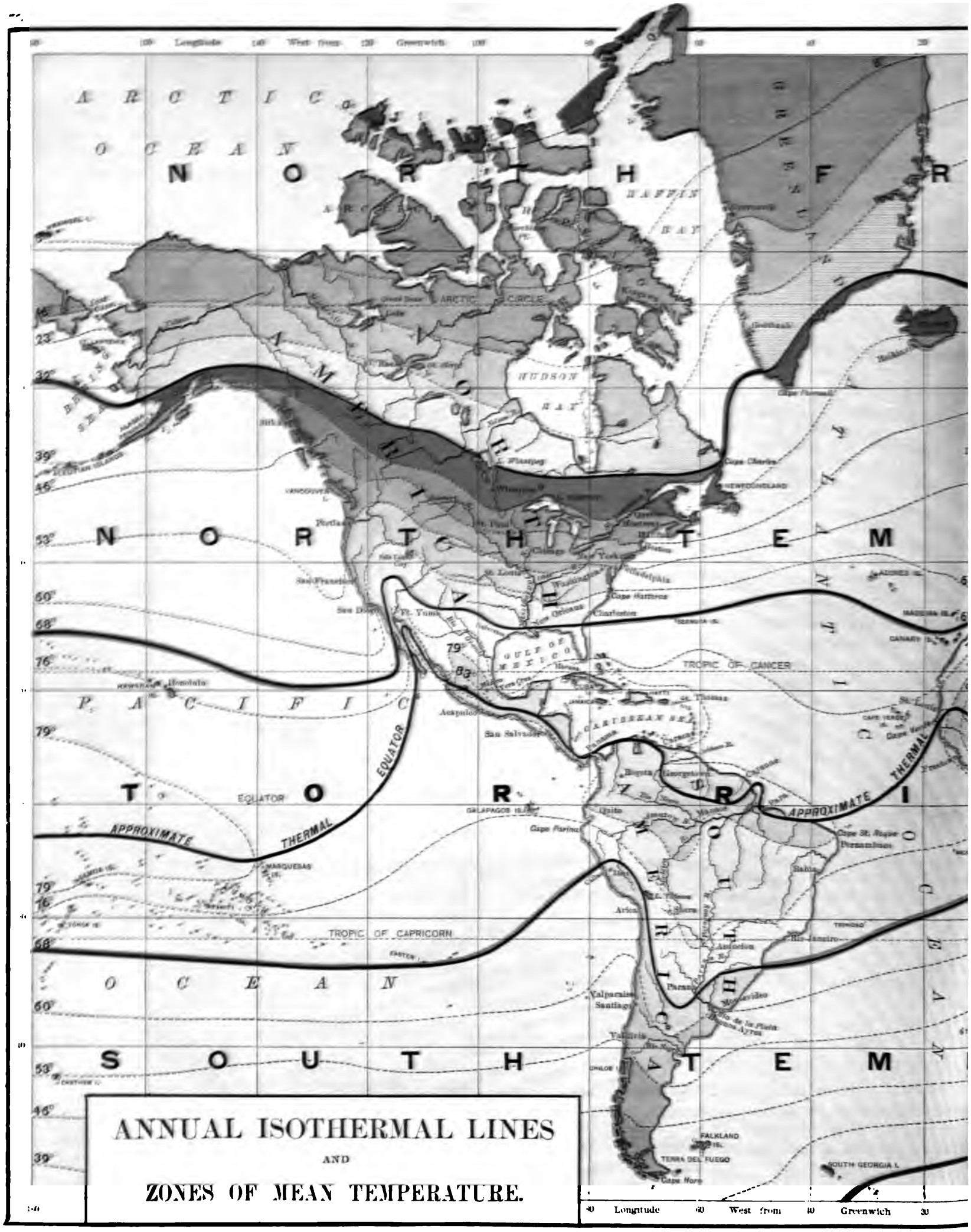
24. Although the isotherms sweep around the earth in such irregular curves, they all indicate a more or less rapid decrease of heat from the equator toward the poles.

In the Northern Hemisphere the isothermal line of 32° is an irregular oval (see map, page 64), which is elongated in the direction of the continents of North America and Asia. On the land this line descends as low as latitude 52°, but off the coast of Norway it ascends as high as latitude 72°. Several places within this oval are known to have a mean annual temperature of zero, or even less; and, from the indicated position of the isotherm for zero, it is believed that the coldest spot in the Northern Hemisphere is situated in the Arctic archipelago of North America, and not at the pole.

The influence of the ocean in directing the course of the isothermal lines can be readily seen in following the curves on the map. The line of 32° in the Northern Hemisphere, just mentioned, ascends from west to east in its course over both the Atlantic and the Pacific ocean. The moderating effect of the Gulf Stream and of the Kuro Siwo carries it up into high latitudes, the former causing it to ascend above North Cape. After this line touches the western coasts of the continents, it descends toward the east. In the Southern Hemisphere the greater extent of the sea causes the more regular disposition of the isothermal lines.

25. Another noticeable feature of the mean annual temperature of the earth, as shown by the map, is the course of the thermal equator, or line of greatest average heat. The temperature along this line is not everywhere the same: the heat is much greater where its path lies over the land than it is where it crosses the ocean. Nevertheless, it forms the dividing-line between the average temperatures of the Northern and Southern hemispheres, and, as throughout the greater part of its course it remains north of the geographical equator, descending but a short distance to the south even when it crosses that circle, it would seem to indicate an unequal distribution of heat in the two hemispheres. Such, indeed, is the case, as is proved by the greater extent of the ice-fields around the south pole as compared with those of the Arctic Ocean.

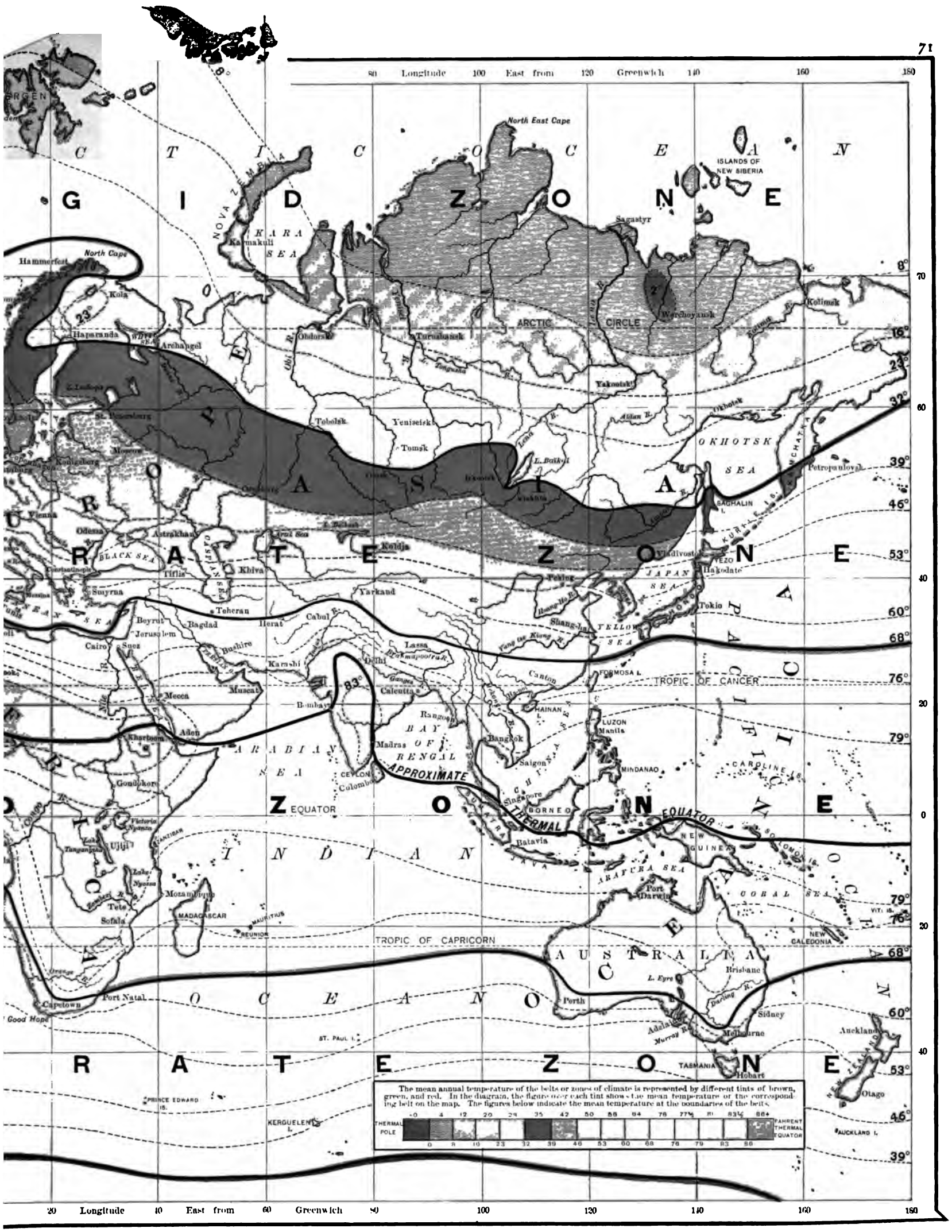
Perhaps the main cause for this inequality of temperature lies in the fact that the Northern Hemisphere contains the greater part of



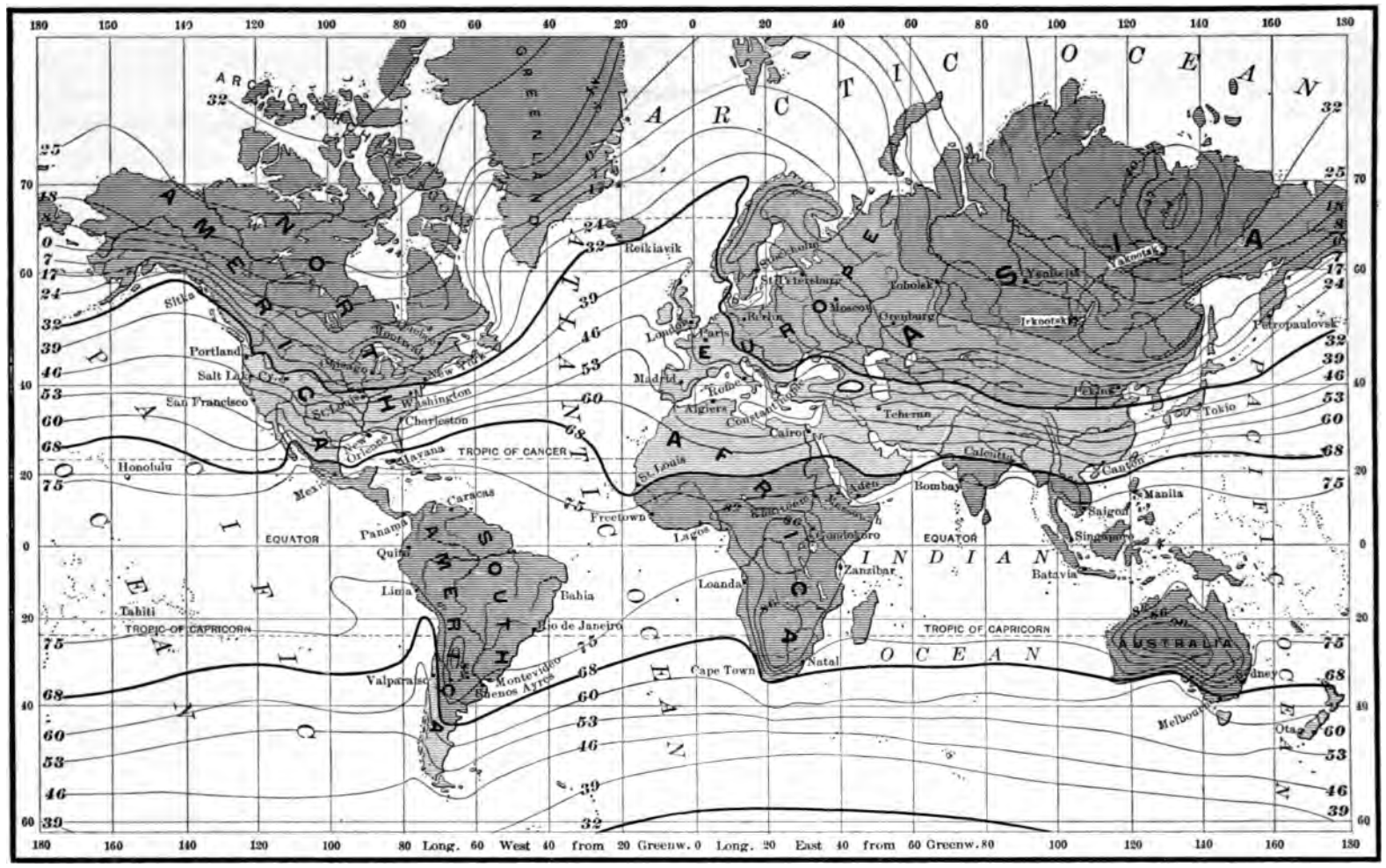
ANNUAL ISOTHERMAL LINES

AND

ZONES OF MEAN TEMPERATURE.



The mean annual temperature of the belts or zones of climate is represented by different tints of brown, green, and red. In the diagram, the figure over each tint shows the mean temperature of the corresponding belt on the map. The figures below indicate the mean temperature at the boundaries of the belts.



the land, while the Southern consists largely of water. The seas of the south are the great area of evaporation, and the continents of the north receive the most of the rainfall. Evaporation is a cooling process; consequently, when the water of the ocean is transformed into vapor, the heat which it received from the sun becomes latent and is carried off by the clouds. As these are borne away by the winds and are condensed over the land, the vapor is precipitated in the form of rain or snow; the latent heat is then liberated, and softens the temperature of the atmosphere where it is set free.

The southern expanse of water has been likened to a boiler, and the northern land-area, with its numerous lakes and rivers, to a condenser, which reduces the vapor and returns it in a liquid form to maintain the perpetual circulation. By the mere fact of their existence, the continents of the Northern Hemisphere attract to themselves the heat and the moisture necessary to sustain the life of the animals and the plants by which they are inhabited; but, as is shown by the isotherms (see maps), they also experience greater extremes of temperature than those of the Southern Hemisphere, whose climate is rendered more uniform by the moderating influence of the sea.

26. Another reason for the greater heat of the northern half of the globe is of an astronomical character. The spring and summer of the Northern Hemisphere are longer than those of the Southern, and on account of the inclination of the earth's axis the hours of daylight in summer exceed the hours of night. The northern land-masses are larger than the southern, and therefore receive more of the summer's heat than they lose by radiation at night, while the contrary is true of the countries in the Southern Hemisphere.

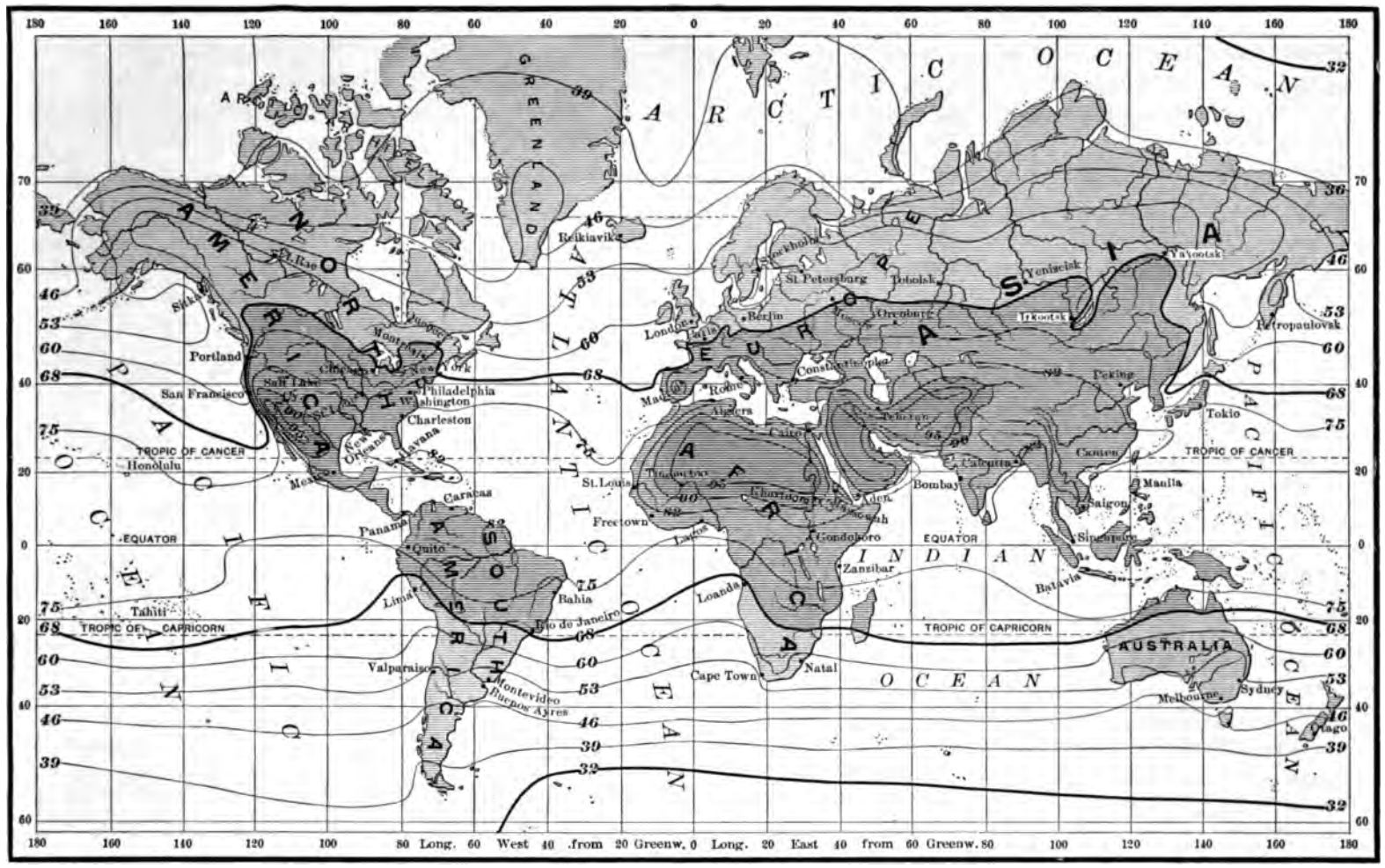
27. A striking difference between the eastern and western parts of the continents is also indicated by the isotherms, and has already *been* incidentally mentioned. The western coasts are rendered warmer through the softening influence of the oceanic and atmospheric currents.

Europe, for ages the theatre of the history of civilization, is especially favored by its situation. Not only are its western shores warmed by the currents and the winds from the equator, but to the north its coast-line is more exposed to the equalizing influence of the water than that of North America with its ice-clad archipelago. It is also along the northern coast of Europe that the drift of the Gulf Stream finally mingles with the polar waters. The many arms of the sea which penetrate this continent, moreover, tend to carry a maritime climate far into the interior. On the south the burning winds from the Sahara, tempered in their passage over the Mediterranean, produce a delightful climate, and even on the east, where it would be otherwise exposed to the varying extremes of the interior of Asia, Europe is protected by mountain-ranges.

28. The **True Character of the Climate** and productions of a country is not necessarily indicated by the mean annual temperature. Two places may have the same mean temperature, and yet differ widely in their extremes of heat and cold and the forms of vegetable life.

New York and Liverpool have the same mean annual temperature, but the difference between the summer and the winter temperature is twice as great in New York as it is in Liverpool. Indian corn, one of the staple products of the United States, will not ripen under the influence of the moderate heat of an English summer. On the other hand, the English ivy, which grows at home luxuriantly throughout the year, frequently succumbs to the severity of an American winter.

The effect of these inequalities of heat and cold upon animal and plant life is noticeable in the difference existing between interior and coast regions which have in other respects the same mean temperature. Those forms of organic life which can support both the rigor of winter and the heat of summer flourish in the interior regions, while such as shrink from extreme low temperature are found only where the climate is softened by the proximity of the sea. The grapes and the fruits of



California are supplanted by the hardier grains in the Mississippi Valley, and the elk is found 700 miles farther north in the Scandinavian peninsula than in the interior of Siberia.

29. The maps of the isotherms for January and for July present some interesting facts. The approximate regularity of the lines in the Southern Hemisphere is maintained in either month, though they move toward the south in January and toward the north in July. In the Northern Hemisphere the greatest approach to parallelism is attained in July; while the contrast between the course of the lines across the oceans, as compared with their position on the continents, is greatest in January.

While the change of position in the two months is comparatively small over the ocean, the land-masses, especially in the north, are subjected to great variations. The most noticeable fluctuations are in the interior.

The isotherm of 32° descends in January below the Great Lakes, in North America, and equally far south in Central and Eastern Asia. In July many places along the same geographical line have an average temperature of 80°, while the line of 68° ascends as high as latitude 60°.

30. The difference between the climate of the land and that of the sea affects the average temperature of the earth as a whole. The Northern Hemisphere, on account of the preponderance of land, has a warm summer, while the Southern Hemisphere, on account of the expanse of water, enjoys at the same time a mild winter. The result is a high average for the season. The northern winter is excessively cold, while the southern summer is moderate, producing a low average. The mean temperature of the whole earth is 62.4° in July, and but 54.3° in January.

31. While the highest mean temperature is found in the vicinity of the equator, the thermometer often rises much higher in the middle latitudes than at places situated immediately on that great circle.

At Singapore, which is almost directly on the equatorial line, the temperature never exceeds 95°; in New York the thermometer occasionally reaches 104°; in California it has been known to rise to 121°; and in India and the Desert of Sahara it rises above 130°.

32. The **Range of Temperature** for the whole year is about 160°; it is least in the equatorial regions and greatest in middle latitudes, where the variation in a single day often exceeds that for the entire year at places near the equator. In some localities the mean temperature for the hottest month differs less than 5° from that of the coldest month; in others, the variation is 50°, or even 100°.

The West India Islands have a uniform temperature of from 70° to 85°, and in Singapore the mean of July differs from that of January less than 4°. At Quebec the range is 60°, and in St. Petersburg the thermometer rises to 92° in summer and falls to 40° below zero in winter, making a range of 132°. In the Sahara, where during the day the heat is extreme, the radiation is so great that ice has been known to form during the night.

Questions.—What is temperature? How is it measured? What is the main source of heat? Do the land, water, and air absorb heat alike? In what three ways is the sun's heat received? What is average temperature? What are the chief circumstances upon which it depends? What is the snow-line? What effect has the sea on climate? What is the effect of ocean currents and winds? What is the mean temperature? What are isotherms? How do the zones of climate differ from the geographical zones? How do the isotherms differ in the Northern and Southern hemispheres? Which hemisphere is warmer? What reasons are assigned for this difference of temperature? What difference exists between the eastern and western parts of the continents? Does the mean annual temperature necessarily indicate the true character of climate? Name some of the marked differences between the temperature for January and that for July. In which month is the total average greater? What is the annual range of temperature?

III. The Winds.

33. **Wind** is air in motion. The air is very easily moved and is very elastic; its equilibrium is easily disturbed, and thus currents of air, or winds, are set in motion. The disturbing causes are chiefly the variation in the amount of heat which the atmosphere receives in different localities, and differences of pressure.

When the air at a given place becomes warmer than that round about it, the warm air expands, becomes lighter, and is forced upward by the surrounding colder and denser air, which then rushes in below from all sides until the equilibrium is restored. In great storms, the wind is directly due to differences of atmospheric pressure which occur in contiguous places.

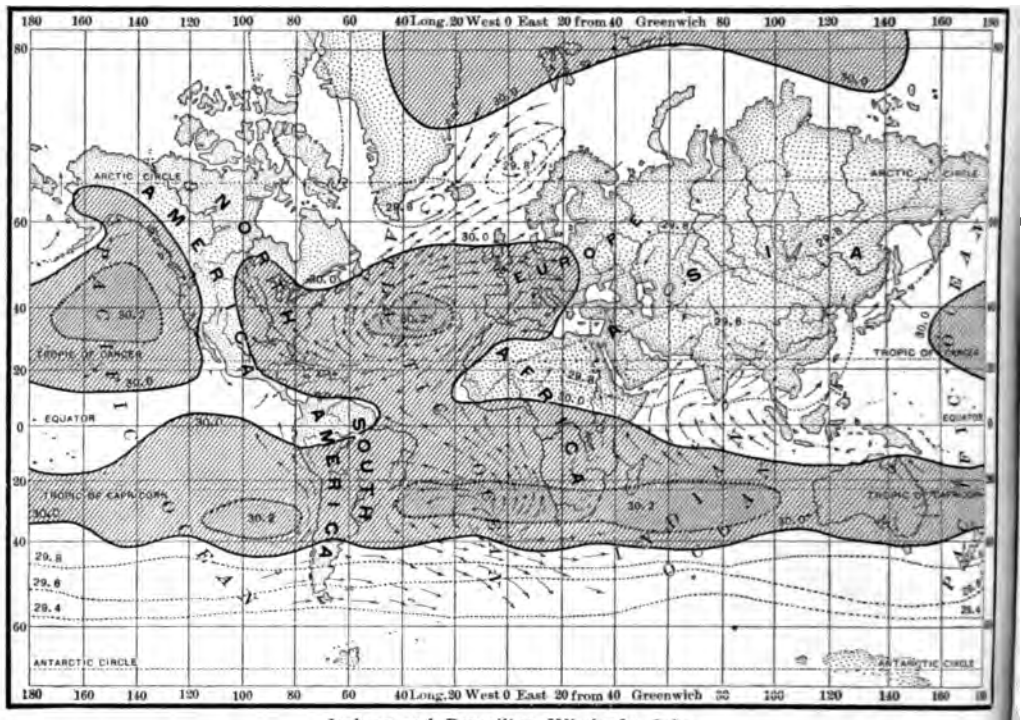
Winds receive their names from the direction *from* which they blow; they thus differ from currents of water, which are named from the direction *toward* which they flow. A west wind is one coming from the west, while a western current of water is one flowing toward the west.

34. As has already been stated, the pressure of the atmosphere is not everywhere the same. This produces winds, because the air will always flow from a region of higher pressure toward one of lower pressure. This will be more fully explained in the section relating to storms, but periodical winds also are as closely dependent on the differences of pressure as on differences of temperature.

35. While the column of mercury in the barometer is in almost incessant oscillation at any given place, thereby indicating continual variations of pressure, yet a mean or average pressure prevails which changes only slightly with the seasons.

This local standard of pressure varies in different parts of the world, and, by connecting on a map places which have the same mean pressure for a stated length of time, the isobars or isobarometric lines, already mentioned, are formed.

On the maps here given the lines enclose areas of equal pressure for the months of January and July, and show the extremes of the average pressure for the year. Notwithstanding the great mobility of the atmosphere, and the furious storms and tempests which temporarily disturb its equilibrium, these lines remain practically permanent from year to year.

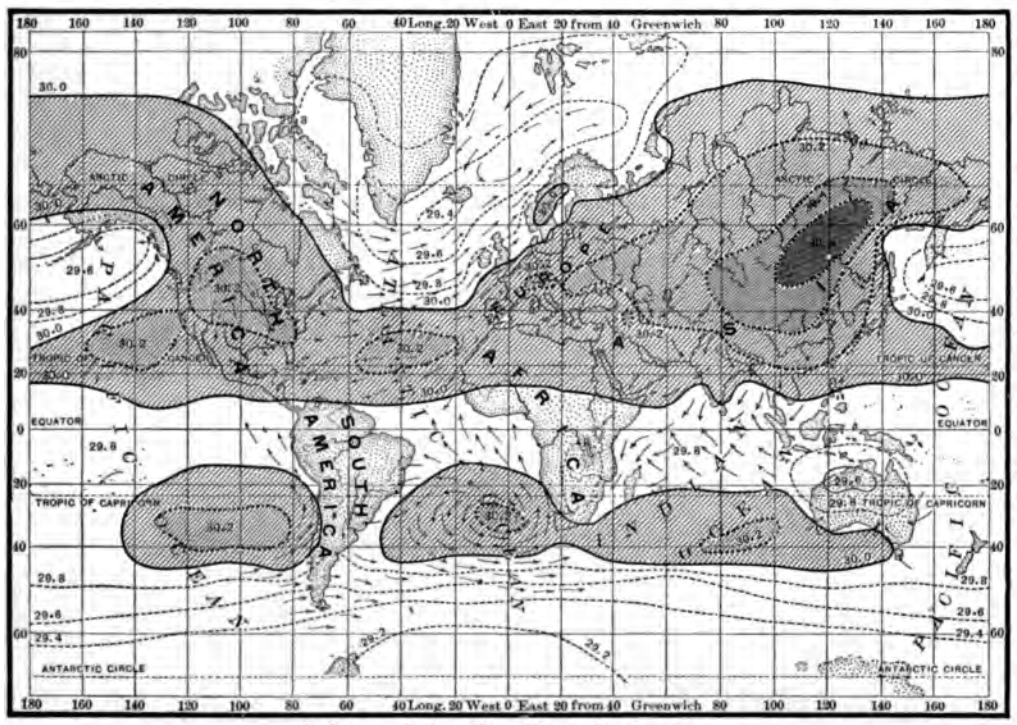


Isobars and Prevailing Winds for July.
(The shaded portions of the map indicate a pressure of 30 inches or more.)

In some respects the isobars are not unlike the isotherms. The fluctuations of the barometric column in the regions near the equator are more regular than elsewhere; and as the range of temperature is less, so also there is but little variation from the mean annual pressure. As the Northern Hemisphere is warmer than the Southern, so too the pressure of the atmosphere is greater north of the equator. The similarity is further exemplified by the fact that the fluctuations are greater in the Northern Hemisphere than in the Southern, and that the greatest regularity prevails over the ocean. The extremes are, as a rule, greatest in the interior of the continents, where the barometer falls from winter to summer, varying inversely as the temperature.

Thus, in January, while Asia is subjected to the extreme cold of winter, the atmosphere, becoming chilled and dry, is condensed, and is relatively heavier than in summer. The mean pressure is from 30 to 30.6 inches. In July, when a high temperature prevails and when the air is expanded, the barometer falls as low as 29.6 inches.

The areas of greatest pressure are found about midway between the equator and the poles. This is probably due in part to the increased proportion of vapor in the atmosphere of the Temperate Zones; and were the air uniformly dry, it is probable that the pressure would steadily increase toward the poles in inverse ratio to the decrease of temperature.



Isobars and Prevailing Winds for January.
(The shaded portions of the map indicate a pressure of 30 inches or more.)

It will be seen on the maps that the tendency of the winds, as represented by the arrows, is to flow away from the belts or areas where the pressure is high toward adjacent areas where it is lower, and that the currents of air cross the isobars.

36. The air is rarely at rest; over most of the earth it is moving in perpetual circulation, and its velocity is vastly greater than that of currents of water. Its movements are caused by changes of temperature and of pressure.

In Fig. 1, *A* represents a spot on the earth's surface which has received heat from the sun to such an extent that it has become relatively warmer than the region surrounding it. The layers of the atmosphere directly over *A* become heated by contact, and expand, pushing up the layers above; the upper layers then tend to flow outward, and thus increase the pressure over *B* and *B′*. As the expanded portion over *A* is now specifically lighter than the surrounding air, it is forced upward, and forms an ascending current. Near the surface the air is expanded over *A* and condensed over *B* and *B′*.

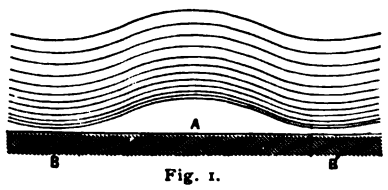


Fig. 1.

As there is a tendency at once to restore an equality of pressure, the air moves from *B* and *B′* toward *A*; the direction of the various motions is indicated by the arrows in Fig. 2. It will thus be seen that surface winds blow toward an area where the pressure is low, and from a region of high pressure, and that above them are counter-currents moving in opposite directions.

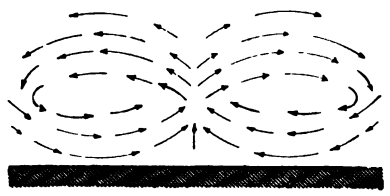


Fig. 2.

37. **Atmospheric Circulation.**—The Torrid Zone receives, as has been previously stated, the greatest amount of heat, and in the equatorial regions, therefore, is found the chief cause of the wind circulation upon the globe. As the air within the tropics becomes heated it expands, and is forced upward by the cooler air which rushes in from both sides to fill the void. There is, therefore, an ascending current, and there are also two lateral currents—the one a northerly, the other a southerly, current. Were not the quantity of air thus drawn from the north and south restored, the whole atmosphere would ultimately accumulate in the tropical regions; but the ascending current, when it attains sufficient altitude, overflows on both sides and forms return currents flowing toward the poles.

This movement of the surface-air toward the equator and of the upper portion toward the poles is illustrated in Fig. 3. If there were no causes to interfere with the flow of the ascending equatorial currents toward the poles and of the return currents toward the equator, the winds of the earth would be only due north-and-south winds, as shown in the diagram.

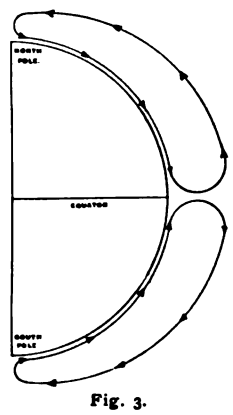


Fig. 3.

Owing, however, to the rotation of the earth on its axis, these currents do not flow directly north and south. This diurnal motion, which is greatest at the equator, gives to the current of air an apparent easterly or westerly direction more or less obvious according to the latitude. Were there no other disturbing elements, the motion of the upper and the lower currents would be in the direction of the arrows in Figs. 4 and 5.

In Fig. 4 a particle of air starting from the pole toward the equator is continually coming to parallels which have an increased velocity of rotation. As it is unable to assume immediately the new velocity, the particle of air falls behind the meridian along which it began to move, and acquires an apparent motion opposite to the direction of rotation.

In Fig. 5 the course of the air from the equator toward the poles is diverted from the meridian along which the supposed particle starts, because it is always meeting parallels where the velocity of rotation is diminishing. The air, therefore, has a greater velocity in the direction of rotation than the earth itself, and so approaches the pole somewhat in the path of a spiral. These motions of the atmosphere are greatly modified by the unequal distribution of land and water, and by other causes.

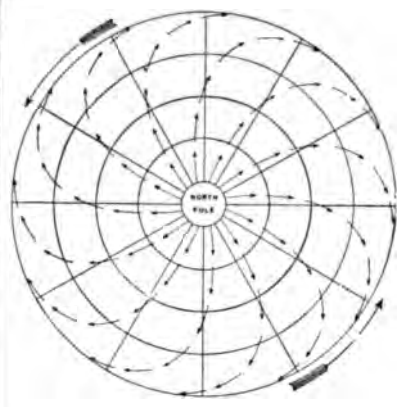


Fig. 4.

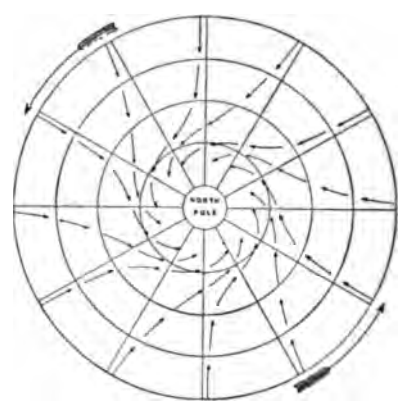


Fig. 5.

38. The upper currents, which start from the equator, cannot proceed without interruption, because, as the meridians converge toward the poles, the air is brought into a more confined space, and is necessarily compressed. As the density increases the weight becomes greater, and over the tropics the accumulation is such that the air descends, though there is reason to believe that in the most elevated regions of the atmosphere it continues its course, as shown in Fig. 3. A part of the descending currents over the tropics returns toward the equator, continuing the circulation, and a part moves toward the poles as a surface current. Near the polar circles the air again ascends, and continues its course toward either pole as an upper current. The surface currents constitute the winds of the globe, and the general circulation is represented in Fig. 6.

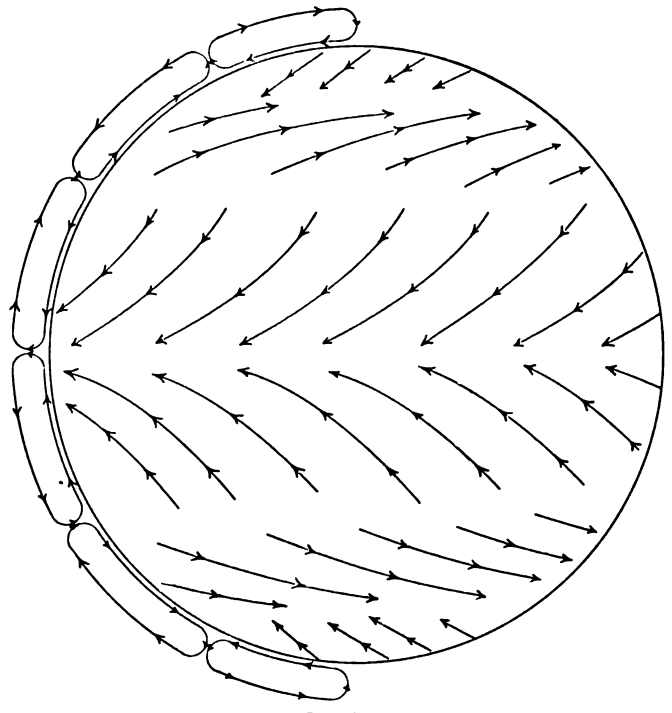


Fig. 6.

39. The winds may be **Regular** and **Periodical,** or they may be **Irregular** and **Variable.** The winds of the sea are more regular than those of the land, and the winds of the tropics are more uniform than those of temperate climates.

The prevailing surface winds are in belts conforming somewhat to the zones of climate, thus constituting three systems: the *tropical system*, the *winds of the middle latitudes*, and the *polar winds*.

40. **The Tropical System.**—Along a rather narrow belt of greatest heat the air is constantly rising; this ascending current is not perceptible, and here are the equatorial calms. (See map of the

winds.) This belt is from 100 to 500 miles wide, and moves to the north and to the south as the sun moves over the tropics.

On either side of this belt the denser air rushes in toward this region of low pressure, and from the revolution of the earth on its axis the air moves to the westward, giving rise to those constant currents known as **Trade-Winds.**

Those of the Atlantic on the north side of the equator are stiff northeasterly winds, forming a belt between about latitude 7° and latitude 29°; those on the south are not so well defined.

The boundaries of the trade-winds vary somewhat with the season, and beyond them, on either side, near the tropics, are other belts of calms. The winds of the Torrid Zone are mostly regular and periodical, their direction and force depending on the seasons.

41. The **Winds of the Middle Latitudes** are, as a whole, westerly winds, but they are much more variable and irregular than those of the Torrid Zone. Those of the Northern Hemisphere are, in general, west-southwesterly winds; those of the Southern Hemisphere, west-northwesterly winds. On the sea they are very much more regular than on the land, and are often called the return trades.

42. The **Polar Winds** are also variable, and are believed to be, as a rule, northeasterly winds in the north polar regions and southeasterly winds in the Antarctic regions; but evidence from actual observation is lacking as to what these winds really are, particularly at the south.

43. The **Monsoons** (so named from a Malay word signifying *season*) are periodical winds modified by the unequal heat of land and sea, in tropical or sub-tropical regions. The name was originally restricted to the periodical winds in the Indian Ocean, blowing part of the year in one direction and part of the year in an opposite direction. It is now used as a general term for winds of this class, of which there are several regions on the globe. These regions are shown on the map of oceanic currents (pages 60 and 61), and the course of the monsoons is indicated by the wavy arrows on the map of the winds (pages 50 and 51). The most important monsoon regions are in the China Sea, the Indian Ocean, the Atlantic Ocean between Africa and South America, and possibly a small belt west of Central America and Mexico.

The monsoons of the Indian Ocean are better known and better defined than any of the others. For five months of the year, when the sun is north of the equator, the highlands and plains of Central and Southern Asia become intensely heated, and a current of air blows across the Indian Ocean, forming southwesterly winds. When the sun is south of the equator, Southern Africa is similarly heated, while the air over the Asiatic Continent becomes relatively colder than that over the Indian Ocean, and for five months the wind is in the opposite direction. Between these seasons for about a month, during which the winds are changing, they are variable. During the season in which the winds blow from the land, the air is very dry and the soil becomes parched; but the winds blowing from the sea are laden with moisture, which falls in torrents and clothes the country with luxuriant vegetation.

44. **Local Winds.**—There are several kinds of local winds. They are less extensive and less important modifications of the general atmospheric circulation produced by causes similar to those already described. The best known of these are the land- and sea-breezes, which are most noticeable in the tropics, but they occur also in summer in temperate seas. During the day the land is generally more heated than the water; the air rises over the land, and a breeze called a sea-breeze flows in from the sea. During the night the land cools more rapidly and becomes colder than the water, and *a land-breeze* flows in the opposite direction.

Similar winds occur between high mountains and hot plains, particularly at the mouths of valleys leading from the mountains. These are very common about the southern portion of the great valley of California.

45. **Sailing Routes.**—A knowledge of the direction of the winds over the ocean and of the oceanic currents is of the utmost importance in navigation. A long series and a great number of observations have been made from which to deduce the best routes for vessels to take in navigating the seas. These routes are not generally the shortest ones, but are planned to take the best advantage of the winds and the oceanic currents.

The average time of sailing-vessels on long routes is now much less than in former years. Maps called *sailing charts*, which give the prevailing winds for each portion of the year, are issued for all oceans, and from them the navigator can calculate the lines along which the shortest trip can probably be made.

Monthly charts of the North Atlantic Ocean (on which there is more navigation than on any other sea) are issued from the Hydrographic Office of this country, giving the direction of prevailing winds for that month, directions as to the best sailing routes, the position of fogs, icebergs, and other hindrances to navigation, for the benefit of commerce and the safety of travelers.

Questions.—What is wind? How is it caused? How are winds named? How does the pressure of the atmosphere affect the direction of winds? What are isobars? In what particulars do they resemble isotherms? Where are the areas of greatest pressure? How does variation of temperature produce currents of air? Where is this cause most prominent in producing the general circulation of the atmosphere? What are some of the causes that modify the general movement of the air to and from the poles? How are winds classified? To what systems do the surface winds belong? Describe the tropical winds. Those of the middle latitudes. The polar winds. What are monsoons? Where are the most remarkable winds of this class? What are local winds? How does a knowledge of the winds affect navigation?

IV. Moisture.

46. **Evaporation.**—If a vessel containing water be exposed to the open air, the quantity of liquid will diminish, and after a time will entirely disappear. The water evaporated is converted into invisible vapor and diffused through the air. The stones wet by a summer shower, the plants covered by the morning dew, soon become dry from the same cause. So evaporation goes on from the ocean, lakes, rivers, the moist ground, and the vegetation over the whole earth.

Matter is said to exist in three states—solid, liquid, and gaseous. Water may be observed in all of these forms: as ice it is solid, as water it is liquid, and as steam or vapor it is gas. There is no real difference between a gas and a vapor; the term is one of convenience, however, because in common language those substances which exist only in that state at a common temperature are called gases, while those gases which may exist in another state at ordinary temperature are called vapors. Thus it is customary to speak of oxygen gas and nitrogen gas, and of watery vapor, the vapor of camphor, etc., because these last-named substances may also exist as liquids or as solids at ordinary temperatures and pressures.

47. **Watery Vapor** is of itself invisible and transparent; it is lighter than the other gases of the atmosphere, but is mixed with them and sustained by the principle of diffusion. Mists and fogs are often called vapors, but, strictly speaking, they are not such.

48. The air is capable of receiving and containing only a certain and limited quantity of vapor; this capacity depends upon its temperature, increasing with heat and decreasing with cold.

Its capacity for containing moisture rises with the increase of heat more rapidly than does the degree of temperature. When the air has taken up as much vapor as its temperature will permit it to retain, it is said to be **Saturated,** and the temperature of this point of saturation is called the "dew-point." If saturated air be

56. **Stratus Clouds** consist of horizontal bands near the surface of the earth, and are more common by night than by day; as a whole, they are lower than cumulus clouds.

57. **Nimbus** or **Rain Clouds** are more dense and heavy than the others, and are nearer the surface of the earth; they are of a dull gray or leaden hue, more or less fringed at the edges.

These various forms of clouds merge into one another and take compound names; thus we have cirro-cumulus, cirro-stratus, cumulo-stratus, etc. All the intermediate forms exist, but the cirrus clouds are the most characteristic type.

The thickness of clouds, as well as their height, necessarily varies with the energy of the causes producing them. They are of all heights, from a fog resting upon the surface to those which have a height of 10 or 12 miles; but most of the cloud-phenomena of the earth occur within 3 miles of the surface.

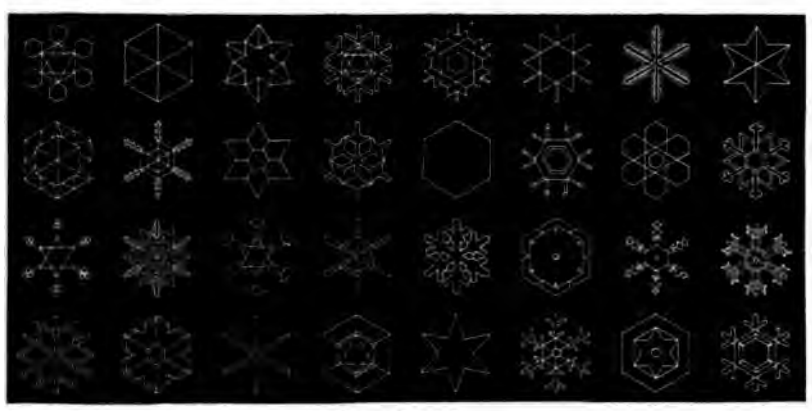
Although heavier than the air, they are supported as dust is supported, and exist only where the air is saturated. Hence, if the particles fall into an atmosphere heated above that required for saturation, they immediately disappear, becoming invisible vapor. So, too, a cloud may remain around a mountain-top, and may not be blown away by the wind; the actual particles forming the cloud are removed by the current of air and disappear by evaporation on one side of the peak, while fresh globules of water are formed by condensation and renew the cloud on the other side.

58. **Rain** is watery precipitation of the moisture from the atmosphere. It is produced by any cause which lowers the temperature of the air below the dew-point continuously for a sufficient time for drops to form.

Warm moist air rising from the surface into the colder regions above loses the capacity for containing the quantity of moisture with which it is charged as vapor, and as it becomes cold the water condenses in drops and falls as a shower. This is the source of rain in the tropics, of the rain of thunder-showers, and numerous other forms of rain.

A warm wind may flow into a colder region, and thus be condensed, producing showers and rain; warm moist winds from the Gulf of Mexico thus produce much of the rain in the Eastern United States. Rains fall more abundantly on mountains than on either plains or plateaus, because the currents of air are raised in passing over them, and, as the air is cooled, rain is the result.

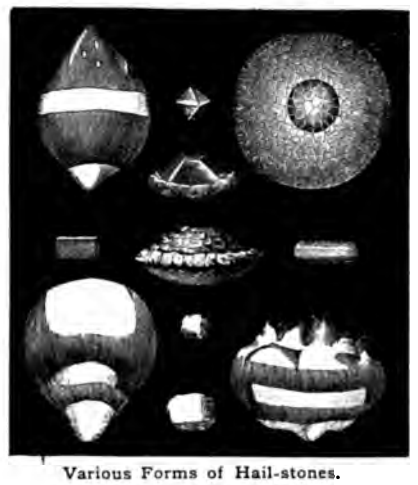
59. **Snow** is produced when the condensation from vapor takes place below the freezing-point (32°), as in the Temperate and Frigid Zones. In the Torrid Zone snow is limited to elevated mountain-districts. Much of the water which falls as rain in our own climate, and even in the tropics, is first formed as snow, which melts by falling through the warmer atmosphere below before reaching the surface of the earth. In mountainous regions a fierce snow-storm over the higher peaks often becomes a rain-storm as it falls through the lower atmosphere into the warm valleys.



Snow-Crystals.

Flakes of snow when collected on dark cloth and examined with a lens or microscope are seen to be of regular and crystalline form, and often of exceeding beauty. Several hundreds of shapes have been described, all belonging to some *variety of six-sided* crystals; the illustration shows a few of the forms.

60. **Hail** is frozen rain, and appears to owe its origin to the sudden condensation of vapor in a strong upward current of air; its fall is generally accompanied with thunder and lightning, and it often causes great damage, and sometimes loss of life.



Various Forms of Hail-stones.

It is believed that hail-stones are formed by the rapid cooling of warm ascending currents of moist air. In the lower regions of condensation rain is formed, and the rain-drops, still ascending with the current, may be frozen into pellets of clear ice, which, when thrown outward from the rising column, may fall directly to the earth. In the higher strata snow is formed by the condensation, and as the ice or the snow falls into the rain-clouds it may be again wafted aloft, receiving additional coatings of ice, until its size is so increased that the weight is sufficient to cause it to fall through the rising current of air.

Hail-stones are of great variety of form and size; sometimes all of them are round, at other times all are of irregular shapes, and a number of different forms may occur in a single storm. Sometimes they are of clear solid ice, at other times of white porous ice, and at still others they appear in bands of alternating clear and white ice, like the bands of an agate. They are of all sizes, from that of the smallest pellet up to that of hens' eggs, and occasionally they are even larger; nearly every year hail-storms are reported in some localities where the hail-stones are as large as hens' eggs.

61. When ice is melted or water evaporated, a large amount of sensible heat becomes latent—that is, much heat is required either to melt ice or to evaporate water; but neither the ice nor the water indicates any increase in temperature until the change of state is accomplished. These processes necessarily withdraw heat from surrounding objects. On the contrary, when vapor condenses to water or water freezes to ice, sensible heat is given out, and these processes therefore tend to warm the air. This law of nature has a great influence in equalizing the temperature by preventing the rapid freezing or the rapid evaporation of large quantities of water, and it also tends to prevent a too rapid melting of snow or condensation of vapor. This also constitutes one reason why moist climates are more uniform than dry climates.

62. Dry air differs materially, with respect to heat, from air containing much watery vapor. Dry air allows radiant heat, whether from the sun or from the earth, to pass through it more readily without absorption than moist air does; hence the sun's rays are more intense in countries having a dry climate than in those where the air is moist. On deserts the nights are often cool because the surface of the earth so readily loses its heat by radiation through the dry atmosphere, and the days are correspondingly hot because of the ease with which the sun's heat passes through to the earth.

The traveler in high mountain-regions, although in a cool atmosphere and surrounded by snow and ice, often has his face blistered by the intense heat of the sun's rays, which pass through the light, dry upper air over the peaks with but little absorption or obstruction.

Questions.—What occurs when a vessel of water is exposed to the open air? Describe watery vapor. What is the dew-point? What effects do changes of temperature produce in saturated air? What is dew? When and where is it formed? What is hoar frost? What are fogs and mists? What are clouds? Into what four classes have they been divided? Describe the cirrus clouds. The cumulus. The stratus. The nimbus. What is rain? When is it produced? What is snow? What peculiarity of form characterizes the snow-crystals? What is hail? How are hail-stones formed? How does change of state in water affect the temperature? How does dry air differ from moist with respect to heat?

It thus happens that so long as there is moist, warm air to be drawn into the ascending whirl, the movement continues. A cyclone often lasts for days, and it ceases when the air sucked in at the bottom is no longer warm enough to cause an overflow at the top of the column. Under such conditions the pressure increases and equilibrium is restored. During its existence a cyclone often travels over a course several thousand miles in extent.

Cyclones are rarely less than 500 miles in diameter, and their breadth is sometimes as much as 1000 or 1200 miles. The area of low pressure at the "storm-center" is relatively great as compared with the shaft of a whirlwind, and the isobars form rings across which the wind blows from all sides.

68. The whirling motion is mainly caused by the rotation of the earth, and is governed by the same laws that control the direction of oceanic and atmospheric currents. (See pp. 62 and 75.) In all cyclones south of the equator the whirl is in the direction of the hands of a watch; in cyclones north of the equator the air moves in the opposite direction.

The progressive motion of these great storms is also obedient to the same laws. On the land, the intervention of mountain-chains and the obstruction caused by various topographical features make the course pursued somewhat irregular, but it is mainly in the direction of the prevailing winds and has a general tendency away from the equator.

69. As the best conditions for the formation of cyclones are to be found where there are extensive areas of calm air which is naturally warm and moist, these storms occur with their most perfect development in the tropical portions of the ocean. Directly at the equator there is no deflective influence caused by the rotation of the earth, hence cyclones are never encountered in the immediate vicinity of the equator. Either north or south of that line, in the belt of equatorial calms, the most favorable conditions exist for great storms to originate, and on account of the broad level area afforded by the ocean, they find over the sea the place best suited for their most violent action.

70. Cyclones originating near the equator in tropical regions have two motions; they follow the general direction of the atmospheric currents, and tend also to move toward the poles. When nearest the equator their progress is toward the west, with an increasing tendency to move toward the pole. When they reach the parallel of 30° they enter the region of tropical calms, or the belt in which there is both an eastward and a westward movement of the winds. As the direction given to the progress of the cyclone by the atmospheric currents is here reduced to zero, the storm follows only its tendency to reach the pole. In the higher latitudes the motion of the atmosphere is toward the east (see Fig. 6, p. 75), and the direction of the cyclone must be toward the northeast in the Northern Hemisphere or toward the southeast in the Southern Hemisphere, with an increasing tendency toward the east as the movement continues.

It may therefore be stated as a general law that cyclones move toward the west and away from the equator in the Torrid Zone, but toward the east and away from the equator in the Temperate Zones. The line of progress is always toward the right in the Northern Hemisphere, and always toward the left in the Southern Hemisphere. The direction of the whirl and that of the forward movement are both illustrated in the diagram.

The difference in direction of the movement of cyclones north and south of the equator is in accordance with a law formulated by Professor William Ferrel, *which may be stated* as follows: "On account of the rotation of the earth, a force is developed which deflects any moving body toward the right in the Northern Hemisphere and toward the left in the Southern Hemisphere."

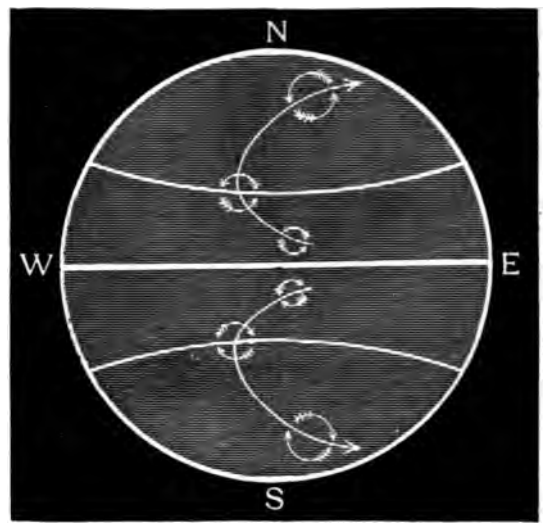


Fig. 8.—The Direction of Cyclones.

It will be seen from the diagram, and from the causes enumerated, that the path of a cyclone over the ocean is in the form of a parabola. It has recently been proved that the shape of the storm itself is commonly elliptical.

The severer cyclones in the Atlantic and the Indian ocean are called "hurricanes;" those off the coast of China and in the Bay of Bengal are called "typhoons." The storm is most intense near the apex of the curve; from this point it increases in diameter and diminishes in severity.

71. With a better understanding of the laws which govern cyclonic storms, and with the very general substitution of staunch steamers in place of sailing-vessels, casualties at sea are less numerous than in former years. The most disastrous effects occur when the cyclone passes from the sea to the land along a low and populous coast. When the storm-center is over or near the land, the winds which blow toward it from the sea pile up the water to an abnormal height along the shore and cause devastating floods. The height to which the water rises is augmented by the fact that—for a time, at least—the shore-line is within an area of low pressure, while the sea at the outer edge of the storm is subjected to an unusually high pressure.

Many floods of this character have occurred in the West Indies and along the coasts of the Gulf of Mexico. The town of Indianola, in Texas, was overwhelmed by a great storm-wave in 1875, and again in 1886. In September, 1889, nearly the whole Atlantic coast of the United States was visited by floods which continued for over a week, and which were caused by great ocean-swells produced by the unusual proximity of a great marine cyclone.

In October, 1737, the water rose 40 feet above the mouths of the Ganges and about three hundred thousand lives were lost; and in October, 1876, two hundred and fifteen thousand persons were drowned by the Backergunge cyclone flood.

72. **Anti-Cyclones.**—Storms often follow one another with but short intervals in their succession. One storm sometimes overtakes another, and the two may become united. Between the storm-areas there exist regions in which the air descends and moves away from the center. As these conditions are the opposite of those constituting a cyclone, such areas are called "anti-cyclones." The air is there clearer and cooler, and the "cold waves" which follow great storms are anti-cyclones.

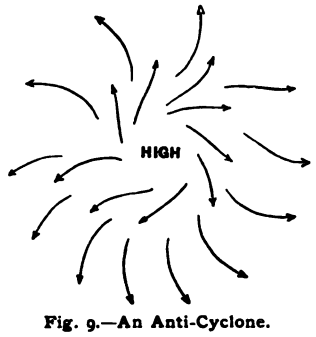


Fig. 9.—An Anti-Cyclone.

73. **Tornadoes** are whirlwinds of small diameter, but intense energy. The conditions which cause the tornado are similar to those which give birth to the cyclone. Indeed, the tornado is believed to be a secondary whirl which originates within the broader cyclonic area. By certain complicated movements of the atmosphere caused by a great storm, a thick stratum of warm, moist air is placed near the surface of the earth underneath a higher layer of much colder air. The gyrating motion in this case begins at the top of the heated layer instead of

Weather-Map, October 23, 1887.

covers a limited spot, and this storm-spot moves over the surface of the earth in the general direction of the great atmospheric circulation.

Could the earth be viewed from some distant point—as, for example, from the moon—where the whole of a storm could be seen at once, the observer would see a patch of cloud denser where the storm was at its height and fading outward in all directions to the fair weather and clear sky that would surround it on every side. He would see, moreover, that this storm-spot would travel over the surface, increasing for a time in size and intensity, then diminishing, and finally disappearing. In its progress it would cover a belt of greater or less width, according to the diameter of the storm. The length of this belt would be seen to be from 1000 to 4000 miles.

This revolving mass of air which constitutes the storm moves onward, but with very uncertain velocity. Some storms travel much faster than others, and any one of them may travel over some portions of its track much more rapidly than over others. Storms sometimes halt in their course for some hours, or even a whole day, and then rush onward again. They usually move with a velocity of from 20 to 30 miles an hour; the average velocity on the sea and on the land is probably not far from 26 miles per hour. A few travel at the average rate of less than 20 miles per hour, and some more than 50 miles per hour. The usual speed of a storm is, therefore, from 500 to 700 miles per day, though the distance traversed in twenty-four hours may be 1000 miles, or even more.

The line over which the storm passes is called the "storm-track," and is usually a curve. Storms originating within the tropics move in a parabola (see diagram, p. 80); those in the United States pursue a devious way, but move, in the main, toward the northeast.

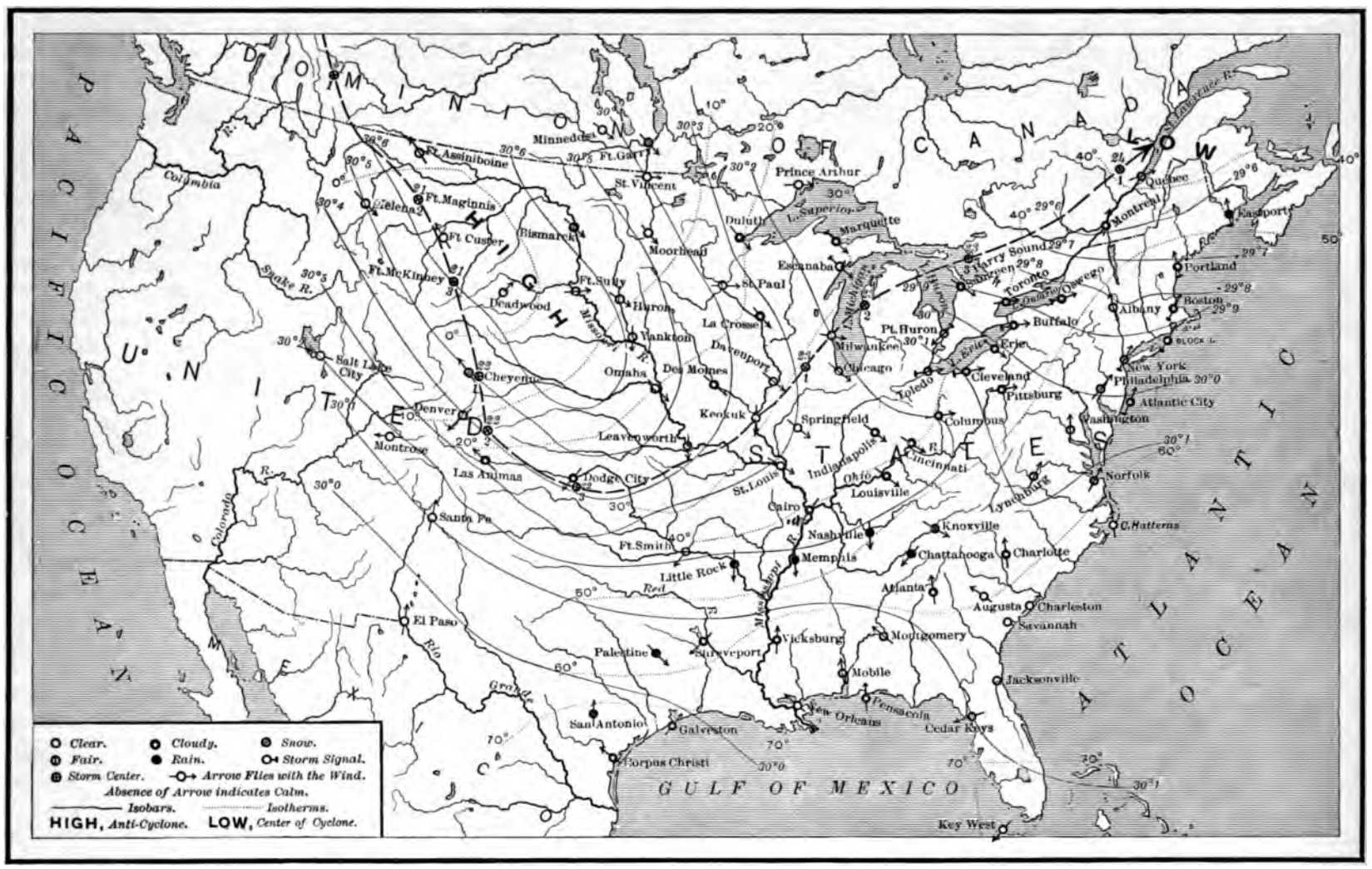
The storms of the United States usually originate east of the Rocky Mountains on the Great Plains; some begin in British America, others as far south as Texas and the Gulf of Mexico. A few originate in the Cordillera region, and a very few in the Pacific, west of our borders. They may move rapidly across the country or they may linger slowly for a while, then hasten on rapidly. They may move in great curves or in devious lines, sometimes changing their course quite suddenly, each storm having a special path, or "track," of its own; yet they do not move at random, and there are some regions more subject to storms than others. On the sea there are special hurricane-regions, and on the land there are belts where they are more common. The great belt of lakes extending from Minnesota to Maine and Labrador in North America is in a path of storms where these tracks are more numerous than on either side. There is a similar region in Russia east of the Baltic Sea. In both these cases the numerous lakes are due in part to the topographical structure of the country, and in part to their being in a belt where numerous storms travel.

81. As storms destroy more life and property than any other disturbances of nature, the importance of weather bureaus is apparent. Any form of signal service is based upon observations taken according to certain methods and at stated intervals.

In the United States the pressure, temperature, degree of moisture, direction and force of the winds, the clouds, and the aspect of the sky are observed at the same instant at various stations throughout the country, and at a few beyond its borders, and at once telegraphed to Washington, where they are recorded on a map of the whole country. The isobars and isotherms are then drawn, and some hours later another map is prepared from another set of observations. A study of the isothermal and isobarometric curves affords the data for predictions for the succeeding day.

82. The maps here reproduced on a smaller scale from the government weather-maps for October 23 and 24, 1887, illustrate the progress of a storm across the country and the method of using weather-observations by the United States Signal Service.

An examination of the map for October 23 shows that the storm had its origin in the Dominion of Canada, north of Montana, and that it moved in a south-



Weather-Map, October 24, 1887.

easterly direction until it reached the northern boundary of Indian Territory, where it turned to the northeast, toward the lake-region. The position of the storm-center is indicated by the symbol ⊕. The figures above the symbol show the day of the month; those below (1, 2, and 3) indicate the times of observation, which are respectively 7 A. M., 3 P. M., and 10 P. M. This map, therefore, shows the course of the storm for the 21st and 22d of October and its position at 7 A. M. on the 23d.

The storm-center is in the middle of an area of low pressure in Illinois. Each of the isobars surrounding this area represents an increase of $\frac{1}{10}$ inch barometric pressure, and areas of high pressure—or "anti-cyclones"—exist in Montana and off the Middle Atlantic coast.

The general direction of the winds in the vicinity of the storm-spot is from the surrounding areas of higher pressure toward the central area of low pressure. The temperature is raised and the isotherms are deflected toward the north ahead of the storm, but they descend toward the south in its wake.

From these observations the indicated path of the storm was toward the northeast across the lake-region, with rain in the Mississippi Valley and in the States east of Missouri and Michigan. Higher temperature was indicated from Ohio to Alabama eastward to the Atlantic coast, and lower temperature in all other districts. Generally, southerly winds were predicted east of the Mississippi and northwesterly winds elsewhere. Storm-signals were ordered at all lake-stations except Duluth.

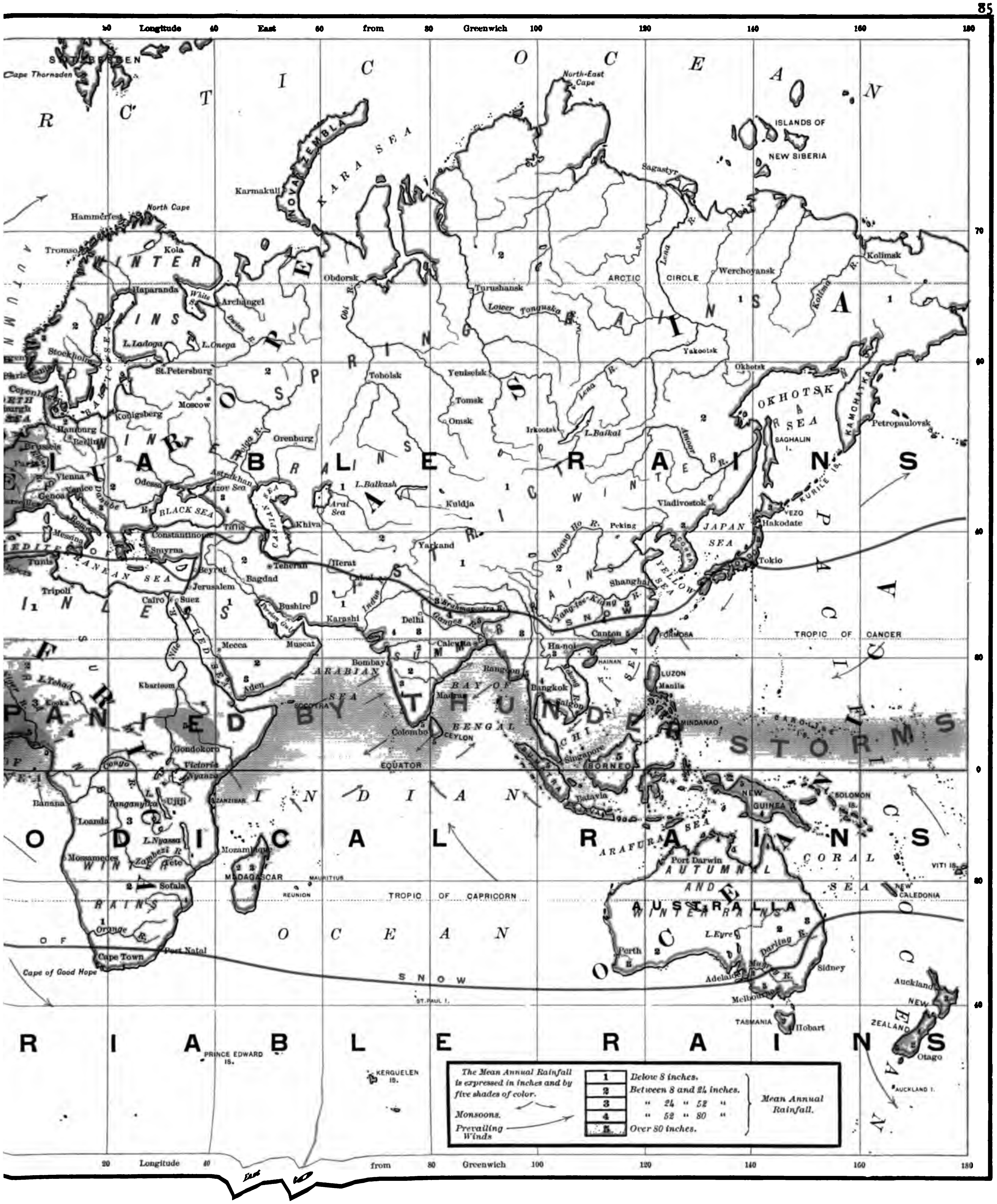
The map for October 24 shows the course actually taken by the storm, and the following synopsis for that day, published by the Signal Service, shows how the indications were realized:

"The storm central yesterday morning in Illinois has moved eastward into Quebec, where the barometer is lowest this morning. A high area of some magnitude has moved southeastward into Dakota, where the barometer-reading is highest. The temperature has risen from the Lower Mississippi Valley east of the Alleghany Range in Pennsylvania, New York, and New England; elsewhere it has fallen. General rains have fallen in the Ohio Valley, the lake-region, and the Lower Mississippi Valley; elsewhere fair weather has prevailed. The winds have been generally southerly in the Southeastern States and on the Atlantic coast, and northerly in all other districts."

83. Smaller storms, such as thunder-storms and tornadoes, cannot be predicted to visit a particular spot at a particular time; it is possible only to indicate the regions where they are most liable to occur. In tropical countries and near regions of periodical winds there are fewer changes of the weather, and rain falls with less change in the barometer, than in either Europe or the United States. The barometer in our latitude fluctuates 2 inches, or even more, in the greatest storms, but in the tropics and during the rainy season heavy rains occur with scarcely any change in the barometer, just as in our own climate there is but little change of pressure accompanying heavy thunder-showers. There is, however, a science of the weather, and most civilized countries have now a weather service maintained by their government. The service is extending from year to year, and at no distant day it will probably be vastly extended in usefulness by international co-operation.

Questions.—What is a storm? What is the chief characteristic of all storms? What peculiar motion is a feature of most storms? What conditions produce a dust-whirl? What is a cyclone? Describe its origin. How is its energy augmented? How are its motions caused? Where are the best conditions found for the origin of cyclones? What law governs the direction of the whirl? Of the progressive movement? Where are these storms most severe? Most destructive? What are anti-cyclones? Tornadoes? How are they caused? What are cloud-bursts? Thunder-storms? Hail-storms? Name some of the other peculiar storm-winds. What discoveries led to the establishment of weather bureaus? Is the motion of storms uniform? Where do most of the storms in the United States originate? Upon what are weather predictions based? Describe the storm represented above.


Longitude West from Greenwich
ARCTIC OCEAN
GREENLAND
BAFFIN BAY
HUDSON BAY
NORTH AMERICA
SOUTH AMERICA
ZONE OF VARIABLE RAINS
ZONE OF CONSTANT RAINS
SOUTHERN LIMIT
NORTHERN LIMIT
PACIFIC OCEAN
ATLANTIC OCEAN
ARCTIC CIRCLE
TROPIC OF CANCER
EQUATOR
TROPIC OF CAPRICORN
BERING SEA
GULF OF MEXICO
CARIBBEAN SEA
HAWAIIAN IS.
Honolulu
GALAPAGOS IS.
MARQUESAS IS.
TAHITI I.
SAMOA IS.
TONGA IS.
EASTER I.
CHATHAM IS.
FALKLAND IS.
SOUTH GEORGIA
TERRA DEL FUEGO
Cape Horn
BERMUDA IS.
AZORES
MADEIRA
CANARY IS.
CAPE VERDE IS.
ICELAND
Reikiavik
NEWFOUNDLAND
Cape Charles
Cape Farewell
Godthaab
Upernavik
Sitka
San Francisco
San Diego
New Orleans
New York
Philadelphia
Boston
Chicago
Charleston
Halifax
Quebec
Montreal
Winnipeg
Vera Cruz
Mexico
Acapulco
Panama
Bogota
Caracas
Quito
Manaos
Para
Pernambuco
Bahia
Lima
Callao
Sucre
Rio Janeiro
Asuncion
Corrientes
Tucuman
Copiapo
Valparaiso
Santiago
Montevideo
Buenos Ayres
Valdivia
Cape Parina
Cape St. Roque
St. Thomas
JAMAICA
CUBA
Havana
Cape Hatteras
Galveston
Portland
Columbia R.
Yukon R.
Great Bear Lake
Gt. Slave Lake
L. Winnipeg
L. Superior
L. Michigan
St. Lawrence R.
Amazon R.
L. Titicaca
Rio de la Plata
WRANGELL I.
ST. LAWRENCE I.
ALEUTIAN IS.
VANCOUVER I.
DISTRIBUTION OF RAINFALL


Longitude East from Greenwich
20 40 60 80 100 120 140 160 180
A R C T I C O C E A N
SPITZBERGEN
Cape Thornsden
NOVAYA ZEMBLA
KARA SEA
ISLANDS OF NEW SIBERIA
North-East Cape
Sagastyr
Karmakul
Hammerfest
North Cape
Tromso
Kola
Haparanda
White S.
Archangel
Dwina R.
L. Ladoga
L. Onega
Stockholm
St. Petersburg
Moscow
Konigsberg
Hamburg
Berlin
Brussels
Paris
Vienna
Venice
Genoa
Rome
Odessa
Danube R.
BLACK SEA
Azov Sea
Astrakhan
Volga R.
Orenburg
Obdorsk
Obi R.
Tobolsk
Turushansk
Lower Tunguska R.
Yeniseisk
Tomsk
Omsk
Irkootsk
L. Baikal
Lena R.
Yakootsk
Werchoyansk
Kolimsk
Kolima R.
ARCTIC CIRCLE
Okhotsk
OKHOTSK SEA
KAMCHATKA
Petropaulovsk
SAGHALIN
Amoor R.
Vladivostok
KURILE IS.
YEZO
Hakodate
JAPAN SEA
COREA
Tokio
Peking
Hoang Ho R.
YELLOW SEA
Shanghai
Yang-tse-Kiang R.
Canton
FORMOSA
Ha-noi
HAINAN
LUZON
Manila
MINDANAO
CAROLINE IS.
Bangkok
Saigon
CHINA SEA
BORNEO
Singapore
Batavia
NEW GUINEA
SOLOMON IS.
Kuldja
L. Balkash
Aral Sea
CASPIAN SEA
Khiva
Tiflis
Constantinople
Smyrna
MEDITERRANEAN SEA
Messina
Tunis
Tripoli
Beyrut
Jerusalem
Cairo
Suez
Nile R.
RED SEA
Mecca
Muscat
Aden
SOCOTRA
Teheran
Bagdad
Bushire
Persian Gulf
Herat
Kabul
Karachi
Indus R.
Yarkand
Delhi
Ganges R.
Brahmaputra R.
Calcutta
Bombay
Madras
Rangoon
ARABIAN SEA
BAY OF BENGAL
Colombo
CEYLON
EQUATOR
L. Tchad
Kartoum
Gondokoro
Victoria Nyanza
Congo R.
Banana
Loanda
Tanganyika
Ujiji
ZANZIBAR
L. Nyassa
Zambezi R.
Tete
Mossamedes
Mozambique
Sofala
MADAGASCAR
MAURITIUS
REUNION
Orange R.
Cape Town
Port Natal
Cape of Good Hope
TROPIC OF CANCER
TROPIC OF CAPRICORN
INDIAN OCEAN
ARAFURA SEA
Port Darwin
AUSTRALIA
L. Eyre
Perth
Adelaide
Darling R.
Murray R.
Sidney
Melbourne
TASMANIA
Hobart
CORAL SEA
VITI IS.
NEW CALEDONIA
NEW ZEALAND
Auckland
Otago
AUCKLAND I.
ST. PAUL I.
PRINCE EDWARD IS.
KERGUELEN IS.
PACIFIC OCEAN
SNOW
WINTER RAINS
SPRING RAINS
VARIABLE RAINS
RAINS ACCOMPANIED BY THUNDER STORMS
PERIODICAL RAINS
AUTUMNAL AND WINTER RAINS
The Mean Annual Rainfall is expressed in inches and by five shades of color.
Monsoons.
Prevailing Winds
1 Below 8 inches.
2 Between 8 and 24 inches.
3 " 24 " 52 "
4 " 52 " 80 "
5 Over 80 inches.
Mean Annual Rainfall.

VI. Distribution of Rainfall.

84. The total precipitation of rain, snow, and hail on any country is called its **Rainfall.** This is distributed very unequally on different portions of the earth's surface; it is distributed unequally both as to season and as to the amount. The quantity is generally expressed in inches per year, which means the number of inches in depth of water (or melted snow) which falls in any place.

In some regions it never rains; in others, again, great quantities of rain fall, sufficient to cover the ground 50 feet deep in a year should none of the water evaporate or run off. In some countries the rain falls with regularity in certain seasons only, while in other countries it falls irregularly during all seasons of the year. The periodicity of rain and its quantity are both caused by the direction and nature of the prevailing winds and by the configuration and elevation of the land.

85. **Periodical Rains.**—In tropical countries and in some sub-tropical countries the rains fall with considerable regularity as to season; the amount of rain varies greatly in different years, but the time of the rains is reasonably constant.

86. In the belt of equatorial calms, where the sun is overhead, it rains almost daily. The ascending current of air, hot and very moist, is cooled as it reaches the greater elevation; clouds appear in the afternoon, then follow frequent and heavy showers of rain, usually accompanied by thunder and lightning.

87. The belts of trade-winds are characterized by almost constant clear weather and deep-blue sky. These winds come from a drier region, and hence the air is clear as it blows toward the rainy belt. The serenity of the trade-zones is interrupted by a short rainy season when the sun comes overhead, while the winters are dry. Within the tropics, therefore, there may be two rainy and two dry seasons each year, or there may be but a single rainy and a single dry season, according to the locality.

88. The sub-tropical zone is characterized by dry summers and rainy winters; during the summer the trades (or the return trades) prevail, the air over the land becomes warmer, and thus its capacity for moisture is increased; but the other and more irregular winds prevail during the winter, by which warm and cool currents are mixed and rain is the result.

Near the tropics or just beyond them, and where there are descending currents of air, there is a dry belt in which lie the greatest deserts of the world.

89. The region of **Non-Periodical** or **Irregular Rains** lies within the belt of variable winds; it includes a portion of the Temperate Zones and the whole area of the Frigid Zones; here either rain or snow falls at irregular intervals at all seasons of the year.

In some of these regions—as, for example, in New England and the Middle Atlantic States—about as much rain falls in one season as in another on the average—that is, about an equal amount one year with another falls in winter, spring, summer, and autumn; in other regions more falls in one season than in another, although the rains are distributed throughout the year.

90. The **Quantity of Rain** that falls in different regions varies greatly. It is measured by a simple instrument—known as the "rain-gauge"—so constructed as to catch the water, and with a graduated scale by means of which it is possible to read the number of inches of rain that have fallen. The amount of snow falling on the same area is carefully melted and the water measured, and this constitutes a portion of the rainfall.

The greatest amount of rain falls within the tropics and on such shores or mountain-slopes as are exposed to winds saturated with moisture. The amount as a whole decreases from the equator toward the poles, but this is not a regular gradation, because of the belts of winds.

More rain falls on the mountains than in level districts, because as the wind is forced to ascend the mountains it becomes chilled and the moisture is precipitated. Mountains in the line of prevailing winds receive consequently more rain on one side than on the other.

Less rain, however, falls on elevated plateaus than on low plains, as the mountain-chains, which usually form the boundaries of high plateaus, have already drawn from the clouds the greater part of their moisture.

For example, the western slopes of the Sierra Nevada and Cascade mountains receive an abundant amount of rain and snow, and are clothed with the grandest forests of the world; while the eastern slopes, which are on the leeward side, are dry, having only scattered trees, and dry and treeless regions stretch inland from their eastern base. So, too, the high Andes stand in the track of the moist equatorial winds, and on their eastern slopes an abundance of rain falls, which feeds the Amazon and other great rivers, while the elevated plateaus between the chains and the western slope near the Pacific are dry and in places rainless.

The most extraordinary periodical rains are those connected with the monsoons. (See page 76.) For five months the hot winds blow over the warm waters of the Indian Ocean and become laden with moisture. They blow across India towards Central Asia, and, encountering the Ghaut Mountains near the coast and the higher Himalayas beyond, precipitate their moisture. Here is found the heaviest rainfall of the world, more than 600 inches falling within the five months, and as much as 150 inches have been recorded in the month of June. The heavy snows falling upon the Himalayas have given them their name. (Himalaya means in the native language "the abode of snow.") These rains feed the Indus, the Ganges, the Brahmapootra, the Irawaddy, and other great rivers of that portion of Asia.

When the sun is south of the equator and the wind blows from the northeast, copious rains fall on the high lands of equatorial Africa, forming the great lakes of that region, and feeding the three great rivers, the Nile, the Congo, and the Zambezi, besides the smaller streams of the eastern coast.

91. The amount of rain which falls within the United States varies from practically none in some of the deserts of the Great Basin to more than 100 inches in some of the mountains of the western and northwestern parts. Over the Eastern and Middle Atlantic States the average amount is between 40 and 50 inches, increasing toward the Gulf of Mexico, and then diminishing westward until portions of the Plains have not more than 10 or 12 inches. (See map of rainfall, pages 84 and 85.)

92. The rainless or very dry regions of the globe lie mostly within the belts of constant and periodical winds. In South America there is a district upon the Pacific shore of Chili and Bolivia which is rainless or nearly rainless for the reasons already stated; in North America there are dry and rainless tracts lying between the mountain-chains which belong to the primary system. Portions of the Great Desert are practically rainless, and very considerable areas have less than 10 inches of rain per year. The largest rainless region of the globe embraces the great desert of North Africa (the Sahara), portions of Arabia, and Persia.

Many sections that are called rainless have occasional showers, sometimes very local and of great severity; such local showers on the deserts of Western North America are often called "cloud-bursts."

93. But little is known of the rainfall of the polar regions. The rainfall in the vicinity of the north pole is probably light, but that of the Antarctic Continent is very much more abundant; it is believed that it snows there nearly every day of the year.

94. Inasmuch as the growth of vegetation requires a certain amount of water, all agriculture depends upon a sufficient amount of rainfall to mature crops. Hence, the quantity of rain determines either directly or indirectly the density of population on the globe. There are some populous regions in dry countries where there are means of irrigating the soil from rivers, but most of the population of the globe is distributed in countries that have sufficient rain to bring crops to perfection. But few crops can be profitably grown where the rainfall is less than 12 or 15 inches per year, and the countries most favored for agriculture are those receiving more than 20 inches per year.

95. If the amount of rainfall in a district is very small, the water may evaporate from its surface and the section be without streams; if more water falls than evaporates it runs away in rivers; if the amount that falls is larger than that which evaporates from the whole drainage-area, then the depressions fill up and the waters overflow and run to the sea; that is the case with most of the regions of the earth. Areas of interior drainage with salt lakes have already been noticed. These tracts lie either enclosed within high mountains, where the air has been dried by the mountains surrounding them, or else on the two belts which extend around the earth a little beyond the tropics.

In the territory east of the Mississippi River from 40 to 60 per cent. of the water which falls in rain flows to the sea in rivers. This abundant water washes the salt and other deleterious substances out from the soil and makes it fertile for agriculture.

Where the amount of rainfall is entirely evaporated, these salts remain in the soil and make it more barren than it would be from mere dryness; hence, deserts of dry regions are very liable to be salt or alkaline.

The causes which produce "basins" or areas of interior drainage lie in the climate rather than in the structure of the country; if there were rain enough, the depression would fill up and at last overflow, no matter how deep it might be or how high the rim. It is the climate that makes the basin rather than the basin that produces the climate. The surface of the land about the Dead Sea and Caspian Sea in Asia, of Death Valley and of portions of the Colorado Desert in California, is below the level of the sea, because there is not water enough to fill these basins. Numerous depressions of this kind exist, which are filled with fresh water because they are in rainy climates. The bottoms of the Great Lakes of North America, of many of the smaller lakes of New York and New England, of Lake Maggiore and other lakes in Europe, are below the level of the sea, but these lakes are fresh because of the abundant rains.

The numerous fresh-water lakes of the Northern United States and Canada, similar lake-regions in Russia east of the Baltic Sea, and the great lake-region of Central Africa lie in belts of frequent storms, as is shown on the storm maps.

The Great Basin of the United States is not one simple basin. Were there sufficient rainfall—more water falling than could possibly evaporate in the region—the depressions would fill up and overflow, forming several water-systems: some emptying northward into the Snake River, others westward through the Sierra Nevada into the Klamath, others through Southern California to the Pacific, and still others into the Colorado River or Gulf of California.

Questions.—What constitutes the rainfall of a country? Is the distribution of rainfall equal in different parts of the earth? How is the quantity of rain expressed? What are periodical rains? Where do they occur? What are the most extraordinary rains of this class? Where are the dry belts? Where are the regions of non-periodical or irregular rains? How is the quantity of rainfall measured? Where does the greatest amount of rain fall? How does the quantity of rain in mountainous regions compare with that of level districts? Which receive the greater quantity of rain, plateaus or low plains? How does the amount of rainfall vary in the United States? Which is the largest rainless region of the globe? What is said of the rainfall of the polar regions? How does rainfall affect the density of population? What becomes of rain? What causes produce areas of interior drainage? What is the character of the climate in lake-regions?

VII. Glaciers.

96. **Glaciers** are rivers of ice flowing from elevated regions of perpetual snow to lower and warmer regions, where they melt.

If the rain of the region (including the snow which melts on the spot) is more than can evaporate from the surface, the surplus runs off, forming rivers; in regions of perpetual snow and where more snow falls than can melt or evaporate on the spot, the accumulation gradually consolidates into ice, which gathers in the valleys and slowly works its way to lower levels, where it melts. This is nature's way of relieving cold regions of the snow which falls, but cannot melt there.

Freshly fallen snow is light, soft, and very porous, being made up of minute crystals, and it drifts easily before the wind. In mountainous countries large quantities blow from the ridges into the valleys, accumulating there to a very great depth. During summer these drifts thaw more or less at the surface on clear days, even on the highest mountains, and the water trickles into the snow below, which gradually changes texture. At first it becomes granular, and finally, from a variety of causes, is compacted into solid ice.

The porous, granular ice is in the beginning white, from the enclosed air, but in the course of time by pressure and the escape of the air the ice becomes firm and clear as crystal. This ice is somewhat stratified owing to the annual fall of snow, and increases in depth wherever the average annual snow-fall is more than a summer's sun can melt.

97. **Motion of Glaciers.**—This mass of ice, or glacier, steadily creeps down the valley at a very slow rate. It moves as a river moves—that is, the velocity is greater at the surface and in the middle than at the edges or bottom, where it is retarded by friction; but the motion is much slower than that of running water—so slow, in fact, that it is proved only by long-continued observation.

Much study has been expended on the investigation of this motion and its causes. The fact that the solid ice flows as a plastic substance might flow is undisputed, but scientists are not entirely agreed as to all the causes.

The onward motion may amount to but a few inches per day, as is the case with most of the glaciers of the Alps, which move usually less than 2 feet in twenty-four hours. The average progress is not so great as that, and only in a few cases does the motion amount to as much as 3 feet per day.

The well-known Mer de Glace moves in the summer 20 inches a day where the slope is gentle, and less than 3 feet where the descent is greater.

The Unter Aar glacier, on which Agassiz made his famous observations, moves on an average only about as fast as the hour-hand of a watch travels. The great glaciers of Greenland and Alaska, however, move much faster—some of them 60, or even 100, feet per day.

98. Glaciers thus slowly move toward the lower valleys and into a continually warmer and warmer temperature, melting on the top, growing thinner and thinner, until at last they suddenly cease. The water formed by the melting of the surface finds its way through the ice by cracks and holes and flows under it at the bottom, emerging at the foot of the glacier, and a river of water begins where the river of ice ceases. In the Alps the glaciers come down the valleys through the forests and between pastures to the very villages, constituting one of the sublimest features of Alpine scenery.

99. Rocks roll from the mountain-side and the rains wash down soil upon the ice, more particularly at the edges. This material is carried along, forming ridges of loose stones and soil known as **Moraines**; those at the sides of the glacier are called **Lateral Moraines.** Where two glaciers come together, forming one mass below their junction, the lateral moraines at the point of junction unite and form a line or ridge on the glacier called a **Medial Moraine.** The material which is carried to the foot of the glacier and

left in a pile where the ice finally disappears is called a **Terminal Moraine.** Some of the rocks thus carried by glaciers are of gigantic size; the loose stones are transported without having their angles worn, as is the case where stones are transported by rivers.

100. It is difficult by mere description to give an adequate idea of the appearance of a glacier. That the solid, brittle ice should flow as water, adapting itself to the shape of valleys, winding hither and thither; now expanding where the valley is wider and then contracting where it is narrower; now passing along a bed that is nearly

The Forno Glacier in the Tyrol.

level, and then over steep slopes amounting almost to precipices, becoming broken, fissured, splintered as it adapts itself to these various shapes of its journey,—constitutes a series of phenomena so unlike those of ordinary experience and observation that only an actual view of the phenomena themselves can convey an adequate conception of the facts.

Below the snow-line, and where the glacier wastes by melting on the top, the surface is like snow, very rough, bearing along with it masses of loose rock and sometimes piles of loose soil; even Alpine plants are sometimes found in the crevices of the rocks or on piles of the soil that are thus traveling down the valley.

The ice is fissured by great cracks, which assume definite shapes where the bed of the glacier has a uniform slope. Some of the largest of these cracks probably extend to the bottom of the glacier; some have been sounded in the Swiss glaciers to the depth of 650 feet; yet by a process known as regelation such cracks may close up and the ice become as solid as if never broken. Where the slope of the bed is steep or very uneven, the ice breaks into huge blocks of many shapes, with chasms between them. The surface-ice is opaque, but within the depths the ice is clear and of a delicate green or bluish-green color.

Near the foot of the glacier it is often possible to penetrate for a considerable distance into these fissures or crevasses, which may form caves of exquisite beauty within the crystal ice.

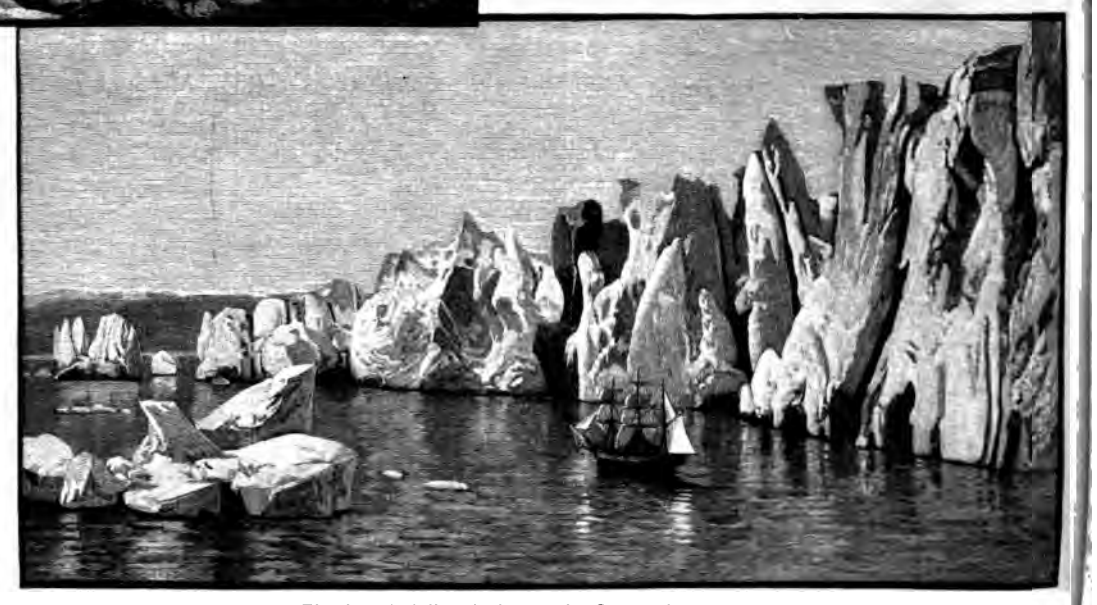
101. Under the glacier the rocks of its bed are ground and polished by the moving mass, and if the glacier is large the stream which issues from its foot is generally gray or turbid with a fine powder that has been worn from the bed or produced by the crushing of loose rocks which are shoved along beneath the ice.

Glaciers thus modify the shapes of valleys by their grinding action, and make peculiar hills by the deposition of the loose material which they carry.

102. The most familiar glaciers are those of mountainous countries, particularly those of Switzerland. More than eleven hundred and fifty glaciers have been enumerated in Central Europe, a few of which are more than a mile wide; some are more than 10 miles long, and the thickest are probably 1000 feet deep.

But they occur in all mountainous countries where there is much perpetual snow. In the Western United States only very small and feeble glaciers exist south of latitude 40°—so feeble that they lack several of the characteristics of larger glaciers; but farther north, in the Rocky Mountains and upon the higher peaks of the Cascades, they are larger. In the higher latitudes they increase in size, until, in Alaska, they are of vast extent and thickness.

There are enormous glaciers in Greenland; one, the Humboldt Glacier, comes down to the sea and for 60 miles forms the coast, rising in ice-cliffs 300 feet above the water. Many other glaciers of Greenland come down to the sea. But it is in the Antarctic Continent that they exist on the grandest scale. This continent is estimated to have an area of 8,000,000



The Sermitsialik Glacier on the Coast of Greenland.

square miles, and is believed to be covered over its whole extent by perpetual glaciers which are thought to be several miles thick.

The Forno, one of the many glaciers of the picturesque Tyrol, is clearly portrayed in the illustration. In the distance its source is visible, and its windings through the mountain-defiles may be traced to the point where the river of ice becomes a stream of water. One of the lofty glaciers which fringe the shores of Greenland is also faithfully reproduced from a photograph by Wm. Bradford.

103. The glaciers of polar regions which come down to the sea-level and push out into the salt water break off in immense masses and float away as **Icebergs.** These masses of ice often cover many acres, and sometimes rise several hundred feet above the water. As seven-eighths of the mass are below the water, some of the icebergs which float down from Baffin Bay toward the Banks of Newfoundland must be more than half a mile thick.

It is, however, about the Antarctic Continent that icebergs are found on the most stupendous scale. The coast of this continent consists of cliffs of ice rising several hundred feet from the ocean and extending hundreds of miles. The surrounding ocean is thick with icebergs, many of them flat-topped, of great extent, and 100 to 200 feet high; their abundance makes the waters of the southern ocean colder than those of the northern.

Icebergs floating from colder to warmer seas constitute one of nature's means of equalizing climate.

104. **The Glacial Period.**—In an earlier part of the present geological era there was a period of intense cold, when glaciers extended over a very considerable part of the Northern Hemisphere. They then covered British America and the Northern United States, much as Greenland is now covered. Their general motion was southward, and they were thick enough entirely to cover New England, flowing over all peaks except, possibly, the very highest of the White Mountains. The southern edge of these glaciers extended to Long Island, Pennsylvania, Southern Ohio, and thence westward.

This glacial period modified the soils and the surface topography of the whole of the region. The hills are rounded, the soils are of mixed materials, generally brought from some point to the northward, and the surface of the underlying rocks is scratched and polished by the great mass which moved over it.

During the gradual wasting away of this enormous amount of ice there were probably abundant rains, and the rivers of the Northern Hemisphere were very much larger than now, and many lakes existed which have since disappeared. Traces of their old shores are seen in the form of terraces at numerous places in North America, and also over Northern Europe and Asia. In New England, especially along the Connecticut River and about Lake Champlain, these terraces are very conspicuous and on an extensive scale.

105. But it is in the far West—particularly in the Great Basin—that we see the most striking evidences of this former abundance of water. Great lakes then existed, which dried away, and their bottoms are now barren, inhospitable deserts. Three great lakes of North America have received names, and have been more particularly studied. The bed of one—known as Lake Agassiz—constitutes a portion of the fertile wheatlands of North Dakota and South Dakota. Two others of great size were in the Great Basin. One in the eastern part, called Lake Bonneville, was more than twice as large as Lake Erie, and overflowed northward, by an outlet, into the Snake River, and thence through the Columbia to the Pacific. The old terraces, or shore-lines, of this lake constitute a conspicuous feature of Utah. Salt Lake is left in a portion of its bed.

Another, in the western part, called Lake Lahontan, had an area of between 8000 and 9000 square miles. It has dried away, and only a few lakes in some valleys, and beds of salt in others, are left.

This period exercised a profound influence on the distribution of animals and plants in the world, and will be noticed in connection with the distribution of life on the globe.

Questions.—What are glaciers? How are *they caused*? What is the character of their motions? What is a moraine? What *is the character* of the ice which composes a glacier? What is the effect of glaciers upon *the underlying* rocks? How do glaciers modify the shapes of valleys? What *glaciers are most familiar*? How many are enumerated in Central Europe? Where are *large Glaciers found in* North America? What is said of the glaciers of Greenland? *Of the Antarctic Continent*? What are icebergs? Where do they attain their greatest size? *Describe the Glacial* period. Its topographical effect. Its effect on rivers and lakes.

VIII. Electrical and Optical Phenomena.

106. **Electrical Phenomena.**—Little is known of the intimate nature of the agent called "electricity," which plays a conspicuous part in various atmospheric phenomena. The study of the laws which govern this agent belongs to the science of Physics. It is sufficient here to say that electricity is not inherent in matter, like weight, but is a condition produced in different bodies by a variety of causes, such as friction, chemical action, heat, evaporation, etc. It manifests itself by attractions and repulsions, by heat and light, by chemical action, by magnetism, and in several other ways.

It is assumed that every mass or body is practically at all times in some electrical state, just as it is assumed that it has a certain condition of temperature. And there are instruments—called *electroscopes*—to test what that state is, and other instruments—called *electrometers*—to measure its intensity.

107. Bodies having more (or less) electricity than surrounding bodies are said to be charged with electricity, or electrified; and whenever thus charged, two kinds of electrical energy, *positive* and *negative*, are developed. Two bodies differently electrified, one positively and the other negatively, have an attraction for each other. If charged with the same kind, they repel each other, and if highly charged and near together, each gives a portion of its electricity to the other, establishing an equilibrium. This interchange of electricity is often accompanied by manifestations of heat, light, and sound.

Electricity passes with great facility through some substances, especially the metals, water, and wet substances. These are called *conductors*. Through other substances electricity passes with very great difficulty, and these are called *non-conductors*. As a matter of fact, there is a gradation from the best to the poorest conductors, for electricity passes through none of them without resistance.

Electricity may exist in a state of repose, and is then accumulated on the surface of bodies, both of conductors and of non-conductors. When moving as a current, it travels through the substance of the conductor rather than on its surface.

If a reasonably good conductor is too small to carry the whole of a large current of electricity, the conductor is heated. The heat may be so intense as to produce vivid light, and it is by this means that the incandescent electric lights now in general use for illuminating purposes are produced. When a current passes through a very poor conducting medium, this medium is liable to be broken or torn in pieces.

108. **Atmospheric Electricity.**—The atmosphere always contains free electricity, which is generally positive, but sometimes negative. It differs in intensity with the time of day, with the season of the year, with the state of the weather, and with various other causes. The surface of the earth is always negative, but the air above may be either positive or negative. At a few feet above the level of the ground and in clear air positive electricity is slightly manifested. At greater elevations the intensity increases, reaching its maximum over the summits of mountains.

In clear weather the air is positive, and is rarely, if ever, negative; in cloudy weather it is also generally positive, but is sometimes negative, and may change from one to the other state with very great suddenness. Positive electricity is more strongly developed in the air in winter than in summer. Free electricity is rarely found in the air in houses, in the streets of great cities, or under trees, and most of the observations of negative electricity have occurred during rainy weather. Various explanations have been made to account for the free electricity in the atmosphere, but the phenomena have not been as yet satisfactorily explained, and scientists are not agreed as to the actual causes.

109. **Thunder and Lightning.**—Clear, dry air is a non-conductor, and its free electricity cannot accumulate so as to acquire great intensity. When clouds form, the free electricity which was in the air accumulates on the surface of the clouds, and may then develop great intensity.

If two clouds differently electrified approach within a certain distance of each other, in accordance with a principle called induction their electricity accumulates on the portions nearest each other. When this accumulation becomes sufficiently intense to overcome the resistance of the atmosphere between them, an interchange takes place, heat and light are produced, and the violent agitation of the air causes the accompanying sound. These constitute the phenomena of lightning and thunder. A similar interchange of electricity frequently takes place between a cloud and the earth.

The lightning is produced by the passage of electricity through the air, which is a very poor conducting medium. This air is suddenly rarefied by the intense heat, and sound is produced in the same way that it is produced by any explosion. The rumbling of thunder is largely due to echoes from the surface of the clouds. The sound of thunder is much less intense than it appears to be. The loudest thunder is not heard at a distance of more than from 12 to 15 miles, while the discharge of heavy cannon is audible at three or four times that distance. The duration of a lightning-flash is probably not more than the thousandth part of a second.

A Flash of Lightning.
(*From an instantaneous photograph.*)

Lightning takes various popular names, according to its appearance—*zigzag lightning* when the flash pursues a zigzag course in the atmosphere; *sheet lightning* when it illuminates a large surface of stratus clouds.

So-called heat lightning, seen in warm summer evenings, is simply the illumination of the atmosphere by the lightning of a thunder-storm so distant as to be below the horizon.

Various other forms of electrical phenomena have been described, such as *globular lightning* and *St. Elmo's fire.*

110. **Thunder-Storms** take place during hot, moist, rather still weather. They are always local and in narrow belts, generally but a few miles in width. They are most frequent in the belt of equatorial calms, and diminish in number and intensity toward the poles. They are less frequent in regions of periodical winds; hence they are rare in such sections as California.

There are usually vivid displays of lightning in tornadoes, hail-storms, and all other intense local storms in which a rapid condensation of moisture is going on. For a similar reason vivid flashes of lightning and terrific thunder often take place during volcanic eruptions, the rapid condensation of large quantities of vapor ejected from the crater furnishing the source.

Lightning usually strikes the highest points; hence church-spires, houses, the masts of ships, and trees are frequently struck, and much damage to property and loss of life often result. Lightning, like all forms of electricity, follows, as a rule, the best conductors, and this suggests the means of protection.

111. **Lightning-Rods.**—Benjamin Franklin, who first discovered that lightning and electricity were the same agent, invented the lightning-rod in 1755, since which time it has been in general use.

The lightning-rod is a metallic conductor extending above the object to be protected and terminating with points, the lower end buried deeply in the ground. Its office is simply to convey the electricity harmlessly from above the building to the earth.

A good lightning-rod is a sure protection, and will protect a circle about it having a radius twice as great as the height of the rod above the building.

112. The **Aurora Borealis,** or Northern Light, is a flickering light of varying intensity seen in the north. Its appearance is not uniform. At times it is a mere arch of light near the northern horizon; at other times streamers extend up to a point near the zenith, sometimes illuminating the whole heavens with variously-colored luminous bands, which are among the most beautiful of atmospheric phenomena. These streamers assume the same direction in the atmosphere as that taken by a dipping-needle. The lower end is near the earth, and the upper end is generally less than 50 miles high; but it may extend to the height of 500 or 600 miles, and thus furnish an evidence of a greater height of the atmosphere than is obtained by any other means. These displays are in some way related to the magnetism of the earth, to electrical currents existing in the earth, and perhaps to certain phenomena taking place on the sun.

The Aurora Australis occurs in a similar way in the Southern Hemisphere, but has been less studied. Auroras are seldom seen in tropical regions, but have their most frequent occurrence between latitudes 50° and 60° north on the meridian of Washington, and on the meridian of St. Petersburg between 60° and 75° north. They then diminish in frequency and intensity toward the pole.

113. **Transparency of the Atmosphere.**—The gases of which the atmosphere is composed—nitrogen, oxygen, carbonic acid, and watery vapor—are all of them colorless and perfectly transparent, and hence invisible. But the atmosphere itself, even in the clearest weather, is never perfectly transparent, because particles of dust are always present in the air, as are also the clouds and crystals of ice and of snow in the upper regions.

From the broad valleys in California and the Great Basin the mountains are in full view and very distinct on clear days in winter and early spring. Later, in the long rainless summer, although the sky is cloudless and the air seems clear,

the same mountains are entirely invisible, and everything distant is shut out by a haze which limits the horizon to a very few miles. At this time of the year, when seen from the summit of high peaks—as, for example, Mount Shasta, Lassen's Peak, or Mount Whitney—the valleys seem filled with an ocean of dust a mile or more deep. Its surface and shores are poorly defined, but its substance is very distinct. Its dust particles are illuminated by the sun in such a way as to make them plainly visible.

In the early summer the color of this ocean is light gray, but later in the season it becomes blue from a greater admixture of smoke, and it varies in its aspects over different valleys or deserts. It also changes with the season of the year and with the time of day. Out of this distinct yet vague ocean distant mountains rise into the clear upper air, and from heights of 10,000 to 15,000 feet peaks which are 150 miles, or even 200 miles, distant are often distinctly visible.

On islands the air is clearer than over the interior of continents, and the atmosphere of sections where the prevailing winds blow from off broad seas is clearer than that of places where the winds are from the land. In India peaks of the Himalayas are sometimes seen sharply distinct at a distance of more than 230 miles, and in the survey of California, signals were exchanged so as to be understood between Mount Shasta and Mount St. Helens, 192 miles distant.

114. Particles of dust and floating matter sustained in the atmosphere by its own motions and by friction not only interfere with its transparency, but produce a great variety of atmospheric phenomena.

115. The **Color of the Sky** is due to particles of dust, of moisture, or of ice floating in the air. The dust, if fine enough, polarizes, scatters, or otherwise interferes with the waves of light. Particles of different sizes produce different effects of color, the coarser producing the reds, the finer the yellows, the blues, and the violets.

Beyond the atmosphere space is invisible. If, therefore, the sky could be viewed from space, it would appear absolutely black; there would be nothing to scatter the light or reflect its rays to the eye. At sea and in low countries in ordinary weather, and at midday, the sky is light blue near the horizon, the blue becoming intenser overhead. The blue color also becomes deeper when the atmosphere is observed from mountains, and is intensely "azure blue" at altitudes of 5000 to 10,000 feet. At still greater heights the sky becomes a deep blue-black, with a faint indigo or violet tinge in the very clearest air at altitudes above 12,000 feet. This is due to the fact that the particles of dust are finer and more uniform at great elevations.

There is a wonderful variety and also a marvelous beauty in the different aspects of the sky, more especially near the time of sunrise and sunset, and the effects are most varied in the interior of the continents and where the dust and haze are most abundant.

In very dry weather the sun usually sets as a red or yellow ball, according to the character of the atmospheric dust, and this spectacle is as common on the sea as on the land in certain climates. Large quantities of smoke increase the redness, while the effect of a yellow, and even of a green, sun is sometimes produced by dust of other texture, especially by volcanic dust. The sun-glows and red sunsets which followed the eruption of Krakatoa in 1883 were noticed all around the earth.

It must be remembered that minute crystals of snow or ice in the upper air may play the part enacted by the dust in the lower air, and it is reasonably certain that they are the chief cause of certain optical phenomena. That peculiar brilliancy in the Arctic sky seen over vast fields of ice or snow, and known to Arctic travelers as *ice-blink*, is probably due to a similar cause.

116. **Twilight** is due chiefly to the reflection and scattering of the light from floating particles in the atmosphere, though its duration and intensity are modified by the refraction of the rays in the different strata. When the sky is pale, thus indicating an abundance of dust or other suspended matter in the air, twilight is long. It is shortest at the equator, often lasting but fifteen or twenty minutes, and it is longest in high latitudes, where in summer it lasts throughout the night. It may be said to terminate in the temperate zone when the sun is 17° or 18° below the horizon; in the tropics it ceases before the sun has descended so far; and in the polar regions it continues till the sun is still farther below the horizon.

117. **Relations of Dust to Moisture.**—In describing the formation of fogs and clouds (see p. 77) only part of the conditions were given. Moisture is condensed when the temperature of the atmosphere is reduced below its point of saturation, but fog and cloud are formed only when there are particles of dust or smoke in the air on which the moisture can condense. By artificial means air may be entirely purified from dust or motes, and when it is in such condition no fog or cloud is produced by cooling it below its point of saturation.

The densest fogs known are those produced over cities, and notably over London. In still, cool weather, when the air is saturated with moisture, and at the same time loaded with smoke and dust from the city, the fog sometimes becomes so dense that objects 10 feet distant cannot be seen; the sun's rays cannot penetrate the gloom, and the day becomes almost as dark as midnight.

118. The **Shadow of the Earth** may often be seen projected against the western sky before sunrise or in the east after sunset. It is of a dark-blue color below the more illuminated portion of the air above, which may be light blue or of various shades of red or yellow, according to the character of the dust.

The shadow of a high mountain is often beautifully distinct either at sunset or at sunrise when seen from the summit. If the mountain is high, the shadow stands up against the sky of deep cobalt-blue, sharply contrasted with the lighter blue of either side where the floating dust is illuminated by the sun.

About some mountain-peaks mists form in such a way that shadows are conspicuously projected upon them. The famous "Spectre of the Brocken," seen at sunset from a peak in Germany, is but the shadow of the observer himself cast on a faint cloud against the eastern sky. The more famous shadows seen about Adam's Peak, in Ceylon, at sunrise, are produced by a similar cause. They play an important part in the religious ceremonies of the island. Buddhist priests live upon the summit, and crowds of pilgrims are there every morning during the fine weather of the northeast monsoon (when the shadow is to be seen) to salute the rising sun and see what is believed to be the miraculous representation.

The dust and floating particles of the air also exert an important influence in various other matters relating to climate or atmospheric effects. It is now known that certain infections which are carried by the air are caused by the floating solid particles, and not by the gases themselves; and it is probable that in certain regions the unwholesome influence known as *malaria*, and the various miasmata that make some climates unhealthful, are due to such particles, and not to gases or vapors.

119. **Coronæ** and **Halos** are colored rings or circles sometimes seen around the sun or the moon. They are caused by the diffraction of the rays of light in their passage through the small interstices between the particles of condensed vapor or snow-crystals. They occur when the sky is partially covered by light, fleecy clouds, showing that the air is saturated; and hence there is a common belief that a distinct halo portends rain.

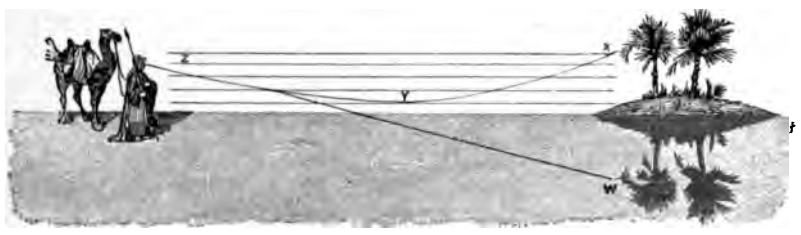
120. **Parhelia** are circles or portions of prismatic circles formed around or near the sun or the moon. They are of larger size than coronæ, and present a much greater variety of appearance. Sometimes arcs of different circles cut one another, and at the places of intersection there are brighter spots, known as *mock suns*. These various appearances are caused by the minute crystals of ice and snow which float in the upper air and reflect or refract the light of the sun or the moon, as the case may be. They are most common in polar regions, but are occasionally seen in the middle latitudes, more particularly at considerable altitudes.

121. **Rainbows** are produced by the decomposition of the sun's rays in rain-drops. Although, perhaps, the most beautiful of atmospheric phenomena, they have no meteorological significance.

122. The name **Mirage** is applied to a variety of atmospheric phenomena occurring when the air is still, and when the layers of atmosphere near the surface of the ground are unequally heated. This inequality of temperature in the atmospheric strata causes a bending and reflection of the rays of light, which produce an apparent displacement of objects, sometimes elevating them, at other times depressing them below their actual position. Perhaps the most common kind of mirage is that in which the rays coming from a distant object to the observer are curved upward, causing it to appear higher than it really is. This is called by sailors *looming up*, and distant coasts or other objects ordinarily below the horizon may thus be seen. This effect is produced when the still air near the surface is denser and colder than that immediately above it.

The estimated height of mountains, when calculated by measuring the angle of their elevation from some distant point, is often very much greater than the true height. The error is probably due to the cause just described. The high peaks of the Rocky Mountains of Oregon and California and those of the Himalayas were first described as being much higher than they were subsequently found to be, and the errors of calculation probably arose from this cause.

The kind of mirage, however, which is most often noticed by travelers is the deceptive appearance of a lake of water over sandy plains. This optical illusion is often so complete that a distant shore can be perceived with trees and other objects reflected in the apparent water, and it seems so real that in Africa whole armies have perished when, suffering with thirst, they have rushed toward what seemed to them a refreshing lake, only to find a barren desert.



Illustrating the Mirage.

The diagram indicates the course of a ray of light, which, proceeding from an object at *X*, is first refracted, and finally reflected at *Y* toward *Z*, showing the inverted image at *W*.

The mirage is often seen in perfection over plains of dried grass—as, for instance, over the eastern base of the Rocky Mountains in early spring and in the great valleys of California. Some of the early maps of that State had extensive lakes and swamps located upon them where only dry land exists. It is probable that early explorers were deceived by the mirage. This illusion occurs even over ice, and has been described in the Arctic regions. Inasmuch as it is due to unequal heating of the layers of atmosphere, the effect is easily destroyed by the wind, and it is therefore most common before ten or eleven o'clock in the morning.

Several other optical illusions, some of strange interest and great beauty, are due to similar causes. The two forms of mirage described may take place together, in which case objects, and also their inverted reflection, may be projected against the sky. To this class belongs the celebrated *Fata Morgana* (or *Fairy Morgana*) of the Straits of Messina—a name given in the Middle Ages, when the appearance was supposed to be due to supernatural causes.

Ships projected against the sky in either a natural or an inverted position, visions of armies marching and countermarching, and various other phenomena due to this cause, once regarded as supernatural, have been recorded, and have played an interesting part in the records of history.

Questions.—How does electricity manifest itself? What two kinds of electrical energy are observed? What are conductors? Non-conductors? What is the electrical condition of the atmosphere? What are thunder and lightning? How are they produced? Where does lightning usually strike? How are buildings protected? What are auroras? Is the atmosphere perfectly transparent? How is the color of the sky produced? What causes twilight? Upon what is the formation of fogs and mists dependent? The formation of shadows in the sky? How do solid particles in the air affect climate? What are coronæ *and halos? Parhelia?* Rainbows? Describe the mirage. How is it caused?

IX. Climate.

123. **Climate** is the general condition of the atmosphere prevailing at any place. It relates especially to the temperature, moisture, winds, miasmata, and those other phenomena and conditions that exert a controlling influence on animal and vegetable life.

Weather is the condition of the atmosphere at any place and at any particular time; climate includes all the meteorological conditions, and is therefore the average weather.

Several entirely unlike causes affect the character of the climate, and, as all operate together, their various combinations give an endless variety to the climates of the globe.

124. The most important cause is the **Latitude** of the place. As has already been stated, the climate, as a rule, is warm near the equator and grows colder toward the poles.

Had the earth everywhere a perfectly level surface, and were the surface everywhere of the same character, then the climates would be in regular belts or zones agreeing strictly with the parallels of latitude. But this is not the case, and each of the following conditions prevents this regularity.

125. The **Elevation above the Sea** modifies the climate; the temperature decreases as we ascend (the rate being 1° for each 300 to 800 feet of ascent), and it follows that this cause alone makes the mean temperature of elevated regions lower than that of places in the same latitude at the level of the sea.

The plains about the base of a mountain in the tropics may be clothed with most luxuriant vegetation; the flanks of the mountain may have the orchards, fruits, and forests of a temperate climate, while above these may be found the grass-covered slopes of the higher Alps, and still higher perpetual snows may be encountered. Thus, on ascending a lofty mountain, the successive climates, from tropical to polar, may be found within a few miles.

The climate of plateaus is generally dry and cold and very unlike that of isolated mountains or of mountain-chains of equal height. On plateaus the vegetation is less luxuriant; there are fewer clouds, the atmosphere is drier, the days are hotter, and the nights are colder.

The climate of mountains is more rainy than that of either plains or plateaus, because their slopes cause ascending currents of air, by which the atmosphere is cooled and rain precipitated. The opposite slopes of a mountain-chain in a region where periodical winds prevail have often very different climates and vary greatly in the amount of rainfall. (See page 86.)

126. The **Vicinity of the Sea** exerts, also, an important influence. As has been stated (see page 69), the air over the ocean is more uniform in temperature than that which blows over the land, and hence the climate of islands and of the coasts is more uniform and more moist than that of the interior of continents. The former is called a maritime climate; the latter, a continental climate. Both may have the same mean annual temperature, and yet have very different climates. The climate of places near the sea is warmer in winter and cooler in summer.

127. **Oceanic Currents** also increase the irregularity of the belts of climate which surround the globe. The cold Arctic current coming down from Baffin Bay and Greenland along the eastern coast of North America cools the air and gives to Labrador and to Newfoundland a cold climate. It is also one of the causes which make the winters of New England colder than those of Great Britain and of Ireland. On the other hand, the Gulf Stream warms the air

along the western coast of Europe. It prevents the harbors of Norway from freezing even within the Arctic Circle; it imparts the soft climate to Ireland and Great Britain, and, in connection with the prevailing winds, renders it possible for figs and similar fruits to thrive in Western Europe in the latitude of New York and Philadelphia. From similar causes the climate of Western North America from Alaska to California is milder than that of the eastern side of North America in the same latitudes.

128. The influence of the **Prevailing Winds**—or, what amounts to the same thing, the position of a place in respect to the general atmospheric circulation—also modifies the climate, especially in connection with oceanic currents. This is another reason why the western coasts of the continents in the middle latitudes are more uniform in climate than the eastern coasts, the prevailing winds of the western coasts coming from the sea, those of the eastern coasts from the land.

So, too, along the belts where there are ascending or descending currents there are peculiar climates. The belt of tropical calms, where the currents are ascending, is rainy, and a belt of dry climates and desert countries extends nearly around the earth north of the Tropic of Cancer in the places where descending currents bring down dry air from the upper atmosphere. (See page 86 and Fig. 6, page 75.)

129. The **Relative Distribution of Land and Sea** also exerts an important influence. The land absorbs heat and radiates it more rapidly than the water, and the air is still more easily heated than the land; consequently, the hottest climates are in the larger continents and large bodies of land are warmer than small ones, other things being equal. The Northern Hemisphere has more land than the Southern, and is much warmer. Not only are the hottest places on the earth and those having the greatest mean temperature north of the equator, but the general mean temperature of countries of the Northern Hemisphere is higher than that of those south of the equator.

The shape and the distribution of the land, as compared with those of the sea, have also an important influence. This gives direction to oceanic currents and modifies the prevailing winds. For example, suppose the Isthmus of Panama and the country of Central America to be swept out of existence, and in their place imagine a deep channel through which the equatorial currents of the Atlantic might pass into the Pacific; it is evident that this would change the whole climate of Western Europe, and perhaps also that of Eastern North America.

Inland seas and lakes greatly modify the climates about them. The Great Lakes of North America affect the climate of a large region, and the Mediterranean Sea, which extends into the Eastern Continent more than 2000 miles where otherwise an almost desert country would exist, gives its coasts one of the most salubrious as well as one of the most delightful climates of the earth.

130. The **Direction of Mountain-Chains** is another important factor. Certain differences which exist between the climate of the Eastern Continent and that of the Western Continent are due to this cause, and these climatic differences, taken in connection with other causes, have had a most interesting influence on the relative distribution of life on the two continents, as will hereafter be shown.

The slopes of the mountains, whether to the north or to the south, affect the climate, the slope away from the equator being naturally cooler. This applies on a large scale as well as on a small one, and is one of the causes which produce the cold climate of Siberia.

131. The **Nature of the Soil** is still another cause. Swamps and lands covered with forests and vegetation have more equable climates and are usually cooler than dry soils; and if the country is covered with an especially barren soil and is also dry, it is then subject to greater extremes of heat and cold.

In some cold countries the soil is frozen to a very great depth. At Yakootsk, in Siberia, the ground is permanently frozen 382 feet in depth, the surface thawing to the depth of only a few feet during the short hot summer. At Point Barrow, in Alaska, the temperature of the earth at a depth of 37 feet below the surface appears to be constant at about 12° Fahrenheit. If the temperature increases 1° for each 50 feet of descent below this, the ground would there be frozen to a depth of over 1000 feet.

132. **Unhealthful Climates.**—Life of any kind cannot exist unless there is sufficient moisture, and also sufficient warmth; hence some portions of the globe support little or no life, and of the habitable portions some climates are much more unwholesome to men than others. The different races of men are especially adapted by nature to different climates, but there are some climates that are unwholesome to all races. A swampy region with a hot climate is nowhere inhabited by a vigorous race of men, and such climates are especially hurtful to the lighter-colored races.

A reasonably dry climate, as dry as is consistent with agriculture, with a temperature neither too hot nor too cold and with an abundance of sunshine, is the most salubrious for people of the Caucasian race.

133. For a series of years together the climate of a place is reasonably constant, but the seasons differ in several respects. The average temperature differs one year from that of another but a very few degrees (see page 69), but the rainfall of different years or of the same season in different years differs materially. Over the more fertile portions of the temperate zone the years with the most rain have scarcely twice the rainfall of the very driest years. But in the drier countries there may be four or five, or even eight, times as much rain in some years as in others.

134. There have been great changes in the climate of the earth in the different geological ages. In Tertiary times a mild climate extended so far north that great forests existed beyond the Arctic Circle, and even during the present geological age there was a period of cold climate—such a long, cold winter that ice and glaciers in the Northern Hemisphere reached to below the latitude of New York. (See page 89.) Even since that period there have been changes in the rainfall of some countries.

Regions which are now too dry for satisfactory agriculture once supported dense populations. The climate must have been more rainy when the inhabitants of the pueblos in Arizona, New Mexico, and Utah were at the height of their prosperity, and certain portions of Central and Western Asia, now comparatively desolate, were once thickly inhabited.

The causes of these changes are unknown. They are probably due to astronomical causes, but it is possible that some of them are due—at least, in part—to local changes in the topography of the country or to changes in the shape or the area of the land.

Questions.—What is climate? To what does it especially relate? What is weather? How does latitude affect the character of climate? What effect has the elevation of a place above the level of the sea on its climate? What variety of climate may be observed in ascending a high mountain? What is the usual climate of plateaus? How does the climate of mountains differ from that of plains or plateaus? How does the vicinity of the sea influence climate? What is the effect produced by oceanic currents? By prevailing winds? Why is the climate of the western coasts of continents in middle latitudes more uniform than that of the eastern coasts? How does the relative distribution of the land and the sea influence climate? The direction of mountain-chains? The nature of the soil? What constitutes an unhealthful climate? What kind of climate is most salubrious for the Caucasian race? Which is most apt to vary, the temperature or the rainfall? Is the climate of a region always constant?

REVIEW AND MAP QUESTIONS.

By what is the land- and the water-surface of the earth surrounded? Of what is it composed? What are some of its properties? Describe the barometer.

What instrument is used in measuring temperatures? What different scales are employed? Which is more variable, the temperature of the land or that of the sea? Why? How does the atmosphere acquire its heat? To what is the temperature of the earth's surface due?

How is the temperature of a place affected by latitude? By altitude? What is a maritime climate? A continental climate? How do ocean currents and prevailing winds affect temperature? How is average or mean temperature determined? How is an isothermal map prepared? In which hemisphere, the Northern or the Southern, are the isotherms most irregular? Which of these hemispheres receives the greater proportion of heat? Of rain? Why? Is average temperature a necessary indication of climate? During what season is the lowest average temperature of the whole earth reached? Where do the greatest extremes occur?

What are the disturbing causes which produce motions of the atmosphere? What are isobars? In what region of the earth is barometric pressure most regular? Explain the effect of heat in producing currents of air. What region receives the greatest amount of heat? How does this affect the atmospheric circulation? How is the direction of the winds modified by the rotation of the earth? What interruption in the circulation occurs at the tropics?

Where are regular winds most prevalent? What are the trade-winds? The return trades? What is the cause of monsoons? Which is the most remarkable monsoon region? How are land- and sea-breezes explained? What are sailing-charts? What is evaporation? Upon what does the capacity of air for containing moisture depend? What is saturated air? What is meant by the dew-point? What is the result if saturated air be cooled below the dew-point?

When is dew collected? What causes its deposit? When is it most abundant? What is frost? Name some of the conditions favorable to the formation of fog. What is a mist? What are clouds? What kind of clouds occupy the highest position in the atmosphere? How are cumulus clouds formed? What condition of the atmosphere is necessary for the existence of clouds?

What are the necessary conditions for the formation of rain? Of snow? Of hail? How is the temperature of the air affected by evaporation? By condensation? How is the great range of temperature in deserts explained?

How are inconstant winds produced? What motion do they frequently assume? Where are dust-whirls apt to occur? Describe the formation of a cyclone. What motions does a cyclone have? Describe each. What is a tornado? How are storms observed by the Signal Service?

How does the rainfall vary in different parts of the earth? What is the character of the rains in the tropics? Where are most of the deserts of the world? How are the rains of India and of the lake region of Africa caused? Are dense populations found in dry regions? Why?

What becomes of snow which does not melt where it falls? Describe the motion of a glacier. What are moraines? Describe the erosive action of glaciers. Where are the largest glaciers and icebergs found? When did the glacial period occur?

What are some of the causes that produce electricity or the electrical condition of different bodies? What is the condition of the atmosphere with reference to electricity? What causes lightning? What is thunder? Where do thunder-storms occur? Where are auroras most frequent?

How do floating dust-particles affect the transparency of the atmosphere? The color of the sky? Twilight? The formation of fogs? The spread of infectious diseases? Name some of the forms of mirage.

What are some of the important causes that affect the character of climate? *Have the* conditions of climate always been the same as at present?

(*In answering the following questions consult the maps, pages 50–51, 64 and 65, 70–71, and 84–85.*) What isotherm marks the line of greatest average heat? Trace its course around the earth. On which side of the equator is the greater part of its course?

What isotherms bound the physical zone of tropical climate? Trace these boundaries from west to east. What isotherm forms the northern boundary of the North Temperate Zone? Follow its course. Where is this zone widest? On which side of North America do the boundaries of this zone approach nearest each other? In what part of the Eastern Hemisphere do they attain their closest proximity?

What causes the isotherm of 32° to ascend so far north on the western coast of Europe? On the western coast of the United States? Why does this line descend toward the eastern side of the continents? Which forms the more regular curve, the isotherm of 32° north of the equator or the corresponding line south of the equator? Which is the coldest part of the North Frigid Zone?

What causes the line of 68° to bend northward after it reaches the western coast of North America? Why does the isotherm of 68° south of the equator bend toward the south after crossing the western coasts of South America and Africa? Which is more regular, the line of 68° north or the line of 68° south of the equator? Why? In which hemisphere, the Northern or the Southern, are the isotherms most regular? Why?

What part of Australia has a mean temperature of at least 68° in either January or July? What cities in Europe have about the same mean temperature as New York? In what part of North America is the mean above 80°? Below 32°? Below 0°? In what portion of the earth is the average temperature above 86°? Name five cities having a mean annual temperature of from 39° to 46°. Name five cities with a mean between 46° and 53°. Between 53° and 60°. About what is the average temperature of Washington, D. C., for January? For July? What is the approximate range of temperature in the region of the Great Lakes?

Where are the northeast trade-winds found? The southeast trade-winds? In what regions are the prevailing westerly winds? The prevailing northeasterly winds? Which of these winds are constant? Which are variable?

Where are the equatorial calms? What belt of calms north of the equator? South of the equator? Where is the great monsoon region? Where is the track of hurricanes in the Atlantic Ocean? In the Indian Ocean? Where is the usual course of typhoons?

Where is the belt of constant rains? Where is the zone of periodical rains? Where are the rains variable? In what belt are thunder-storms of frequent occurrence? Where are the rains nearly constant?

In what seasons are rains most frequent in the Eastern United States? In the western part of the Union? When do they occur in the northeastern part of North America? What is the character of the rain along the Pacific coast of Alaska and of the British possessions? In what part of the United States is the rainfall the heaviest? In what section is it the lightest? Why?

What causes the belt of heavy rains extending southward from the Caribbean Sea in South America? Where is the rainless district of that continent? Why is this region so dry? Why is the rainfall heavy along the Atlantic coast in the northern part of the continent? Why are the rains heavy on the Pacific coast in the southern part?

At what seasons of the year are rains most prevalent in Europe? In Northern Asia? In Southern Africa? In Australia? What causes the heavy rains in Eastern Africa and India? What is the character of the rainfall in the islands lying between Australia and Asia?

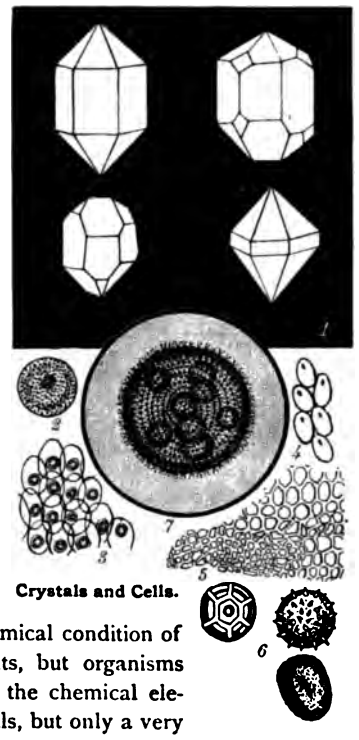
Where is the rainless district of the Eastern Hemisphere? To what is the lack of rain due? Trace the northern limit of snow. The southern limit.

ORGANIC LIFE.

I. The Organic World.

1. The **Organic World** includes everything that has life. All animals and plants, of whatever kind, form, and size, are known under the general name of **Organisms.** The study of their kinds and the relation of these kinds to one another belongs to the science of Natural History, but the study of their distribution on the earth constitutes a department of Physical Geography.

2. **Organisms differ from Minerals** in many characteristics, only the more important of which can here be enumerated. Minerals crystallize with flat sides and sharp angles, while organisms are composed of cells and have rounded sides. Crystals, when they increase in size, grow from the outside and continue to grow as long as the conditions exist, and there is no limit to the size they may attain; while organisms grow by taking nourishment into their interior, have a period of growth which is called their life, and each kind has a somewhat definite size. Minerals when formed may exist unchanged for countless centuries; organisms live but for a while, require continual nutrition while they live, and then die and decay.



Crystals and Cells.

These are, perhaps, the most striking differences between the two; there are, however, numerous other differences. Minerals may be produced from the mere physical and chemical condition of substances containing the necessary elements, but organisms originate only from living parents; again, all the chemical elements known to science are found in minerals, but only a very few of them exist in organisms. Minerals, although containing so many elements, constitute but few species; scarcely a thousand are known, and they are classified according to their chemical composition and crystalline form. Organisms are composed chiefly of the four elements carbon, hydrogen, nitrogen, and oxygen, with but a small proportion of a few others; but these few elements, under the influence of that condition which is known as *life*, form an almost endless number and variety of combinations or compounds. And, moreover, organisms exist in a vastly greater number of kinds; hundreds of thousands have been described, and there are perhaps a million in existence. (See p. 14.)

Again, all parts of a crystal are essentially alike, but living beings have usually different parts, called *organs*, which have different uses; and for this reason they are called *organisms*. For example, a tree has a root, stem, bark, leaves, flowers, fruit, etc.; these parts are called organs, and the whole tree is called an *individual organism*. So, too, an animal may have a head, limbs, heart, stomach, etc., each part or organ having a different use and each one essential to the well-being of the individual or of the species.

In the illustration are represented (1) some of the common forms of quartz crystals, (2) a single cell, (3) a group of animal cells, (4) a group of vegetable cells, (5) a number of vegetable cells changed from their original form by the process of growth, (6) pollen grains, and (7) the *volvox globator*, a microscopic fresh-water plant, which consists of a number of similar and independent cells associated in a larger sphere. All the organic forms shown above are greatly magnified.

Any substance consisting chiefly of carbon, nitrogen, hydrogen, and oxygen, or any three of them, and which has been formed under the influence of life, even if dead and in a state of decay, is called *organic matter*.

3. Three great laws dominate in the organic world. The first is the law of **Heredity,** in obedience to which organisms multiply and reproduce descendants, which grow in the likeness of their parents or ancestors. In obedience to this law successive generations and countless millions of similar creatures come into existence and grow and die; by virtue of it the species continues, although the individuals which compose it pass away.

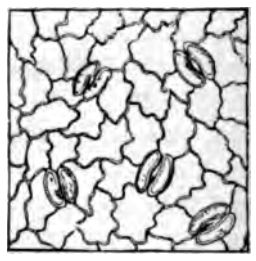
4. The second is the law of **Nutrition,** in obedience to which organisms are nourished or fed. By virtue of this law the individual grows and lives and its separate life is maintained.

Air is essential to the growth of all organisms, except, perhaps, a few microscopic plants. Growth and change of substance occur in connection with death and decay during the life-time of an organism. Portions of the organic structure become worn out and useless. They are destroyed by the active properties of the atmospheric oxygen, and it is one of the offices of the air to remove this dead and effete matter. Air, therefore, both nourishes and destroys.

To compensate for this loss all organisms require food, and it is necessary that the food should contain those chemical elements which enter into the composition of organic matter. As water constitutes at least one-half the weight of any animal or plant, it is one of the essentials of life.

Nutrition and growth are dependent upon a proper amount of heat. Though life may continue to exist at temperatures below 32° or above 150°, growth does not take place.

Sunlight is essential to the well-being of most known species, and without it there is little vegetable growth. The food of the plant consists of carbonic acid and water in which a little mineral matter is dissolved. The former is obtained from the air through little mouths (called *stomata*) in the green leaf, and the latter reaches the plant mainly through its roots. It is only by the action of sunlight on the green coloring-matter (called *chlorophyl*) which is found in the leaves, and sometimes less abundantly in other parts of the plant, that the chemical decomposition of these materials occurs. The carbon of the carbonic acid and the hydrogen of the water are retained in the plant while the oxygen is given off free to the air. Thus, green plants by absorbing carbonic acid not only obtain part of the material for their food, but also withdraw from the air a gas deleterious to animal life, and at the same time renew the supply of oxygen which is necessary for its existence.



Magnified Section of a Leaf, showing the Stomata.

Inasmuch as the nutrition or food of the organic world comes originally from the mineral world, the total amount of plant life must be greater than the total amount of animal life, and plant life must be more abundant on the land, in swamps and shallow waters, where the soil furnishes nutrition for the vegetation. The actual amount of vegetable matter on the land is much greater than that of the animal matter, but in the sea animals are relatively much more abundant.

5. The third law is the law of **Variation,** in obedience to which organisms are modified. They are endowed with a sort of plasticity of nature which allows them to be more or less changed or moulded by surrounding conditions and influences. By virtue of this law individuals grow larger or smaller, according as the conditions are more or less favorable, and varieties are adapted to their environment by successive changes from generation to generation.

These three laws, working together, determine the character of each and every individual organism. The ancestry determines the species and the general form, while the relative size and perfection are determined by the combined influence and abundance of its food and nourishment, and by its inherent capacity to be modified by external conditions.

6. **Environment.**—All things, taken together, which in any way promote or interfere with the well-being of an organism during its life constitute its environment. This term includes its food and nourishment, the climate in which it lives, its enemies, and the other organisms which in any way affect it, either as producing food or as competing with it for food or for living-room.

The ancestry, the capacity for variation, and the conditions of environment each admit of great diversity, and, as a result, we have such a dissimilarity of organisms that it is probable no two are exactly alike in every particular.

7. The organic world is primarily divided into two great kingdoms, the **Vegetable Kingdom** and the **Animal Kingdom.** Plants constitute the vegetable kingdom, and are lower in the scale of being than animals. Their nourishment comes from the mineral kingdom. They are able, as has been described, to transform simple mineral matter into organic matter. They have neither sensation nor power of voluntary motion, and, as a rule, are fixed by roots to the spot where they grow.

Animals are higher in the scale. They cannot live on mineral matter; their food comes directly or indirectly from the vegetable kingdom. They can move at their own will, and probably all are possessed with some sense of feeling. The higher animals are endowed with independent motion, and with senses, like man.

Strictly speaking, some kinds of plants (fungi) live on other plants or on decaying, or even living, animals, and many animals eat other animals; but, as a whole, plants subsist on the mineral kingdom and animals on plants. The two are, in fact, dependent upon each other, animals ultimately depending upon plants for food, and the higher plants in turn requiring for their healthy growth a soil containing decaying organic matter. Both, in their decay, are resolved again into the mineral kingdom, earth, water, and gases.

In the lowest organisms the two kingdoms approach each other so closely that it is uncertain to which of them certain minute microscopic creatures belong. Some species of microscopic organisms, mostly animal, exist in the sea in such vast numbers that their remains, falling to the bottom, produce important strata. Such was probably the origin of chalk, and such was the origin of certain kinds of ooze now forming on the ocean's bed. (See p. 55.)

8. **Flora and Fauna.**—All the plants of a country, of whatever kind or sort, taken together, constitute the *flora* of that country, and their special study belongs to the science of Botany. All the animals, taken together, constitute the *fauna* of the country, and their special study belongs to Zoology.

9. **Classification.**—The number of individuals is so inconceivably vast and their variety so great that they need to be classified in some manner before their geographical relations can be properly comprehended. Classification is the artificial arrangement of kinds for the purpose of systematic study. Numerous systems have been devised by naturalists, but in all of them a group or kind, called a *species*, is the starting-point.

10. **Species.**—Organisms which resemble one another more closely than they do others, which are capable of a description as a kind, which can be distinguished from all other kinds, and which derive their peculiar characteristics from their parents and transmit them to their offspring, constitute a species. (See p. 14.)

A species consists of many similar organisms; the individuals die, but the species continues. It is a chain or series of organisms of which the links are parents and offspring.

Several hundred thousand species have been described, and it is believed that there are a million in existence; but the greater number are low in the scale of being and inconspicuous to the observer. Some of the species are widely spread over the globe, but by far the most of them belong to some particular land or sea, *and very many* of them are indigenous to only a very small region.

11. There are three theories as to the nature and origin of species, explaining in different ways their geographical distribution on the globe.

The first theory is that each species, by a fiat of the Almighty Creator, was suddenly called into existence, with all of its special characteristics, at some one spot on the globe (called the *center of dispersion of the species*), and that from this center it has spread by various means of migration to the regions it now naturally inhabits. This theory further holds that each species, though capable of slight temporary modifications, is specially designed to inhabit a particular climate and soil, and that it is essentially fixed and unchangeable in its character; so that if the environment becomes unfavorable it dies out, as many species have done in earlier geological ages.

The second theory considers the species even more unchanging than does the first. It supposes that each originated by a special creation of many individuals at several centers and including the different varieties.

The third theory holds that species are not fixed and unchanging—that the capacity to vary allows the species in successive generations to be changed in accordance with natural laws, and thus to become adapted to new conditions. It supposes that new species arise gradually from the old, that the species now living upon the earth are the modified descendants of extinct species which lived in earlier geological ages, and that the life has been continuous from the most ancient geological times.

Many theories of the origin of species have been proposed, but they are all but modifications of these three, differing merely in their details.

12. **Genera.**—Species which resemble one another in certain important characteristics are grouped into a *genus*. For example, there are many kinds of oaks, but all together they constitute the genus which in common language is known as *oak*. In a similar way groups of animal species form genera. The horse, the ass, and the zebra belong to one genus; the ox, the buffalo, and the bison, to another genus.

13. **Families and Orders.**—Genera, in turn, are grouped into families or orders, and these into higher classes, in accordance with more and more general characteristics.

Families and orders also vary greatly in the number of species and genera which they contain and in the wideness of their distribution. Some contain thousands of species and are widely distributed over the earth; others consist of but few species and are confined to a single region or to a single climate.

For example, in Botany there is the rose family (Rosaceæ), which includes hundreds of genera and thousands of species, all having in common certain general characteristics recognized by the botanist. Its species and its genera are also distributed throughout the earth, while the cactus family (Cactaceæ) is found native only on the Western Continent.

Thus the genera of both plants and animals are grouped into families or orders, and these, in turn, into classes, until all living beings are arranged in accordance with a definite system in which every species finds a place, so that it may be described and its relation to every other species be readily understood.

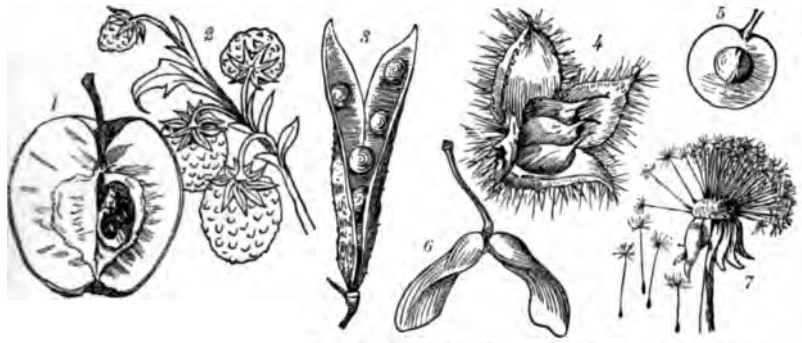
For illustration, an herbarium is a collection of dried plants for study. Several of the larger herbaria of the world contain more than a hundred thousand species and many hundreds of thousands of actual specimens of plants, but the classification may be so complete that any species of this vast collection can be found and referred to in a single minute.

14. The vegetable kingdom is divided into two great branches, the **Phænogamia,** or flowering plants, and the **Cryptogamia,** or flowerless plants. While it is impossible to give here any detailed description of the various species, genera, families, orders, and classes, yet merely to illustrate how organisms are classified the following scheme of the classification of plants is introduced:

- **Vegetable Kingdom.**
  - **Flowering Plants.**
    - Exogens
      - Angiosperms
        - Polypetalous.
        - Gamopetalous.
        - Apetalous.
      - Gymnosperms.
    - Endogens
      - Aglumaceous.
      - Glumaceous.
  - **Flowerless Plants.**
    - Acrogens
      - Vascular.
      - Cellular.
    - Thallogens.

All systems of classification are artificial, and many descriptive words remain in use which were first applied when scientific knowledge was comparatively meager, and which now, if considered too strictly, may convey technically a wrong impression. For example, the difference between flowering and flowerless plants is not so sharp as was once believed, but these old terms are retained because they express a general fact and in connection with it have become part of the language.

15. **Flowering Plants** constitute the most conspicuous vegetation of the globe. They are characterized by producing flowers and



(1) *Apple.* (2) *Strawberry.* (3) *Pea.* (4) *Nut.* (5) *Cherry.* (6) *Maple.* (7) *Dandelion.*

Various Forms of Fruit and Seeds.

seeds. Some flowers are among the most brilliant and beautiful objects of the organic world; others are inconspicuous. The essential feature of a seed is that it contains the embryo of a new plant, and thus the species is continued.

The seed and the seed-vessel of a plant constitute its fruit. Nature provides various forms of fruit for disseminating the seed, which is sometimes enclosed in a core within a pulpy envelope, like the apple, or sometimes found on the outside of a fleshy enlargement of the extremity of the stalk, as in the strawberry; the outer shell sometimes becomes a pod like the pea, or hardens like the nut, or, remaining pulpy, contains a stone-fruit like the cherry. The fruit is sometimes winged like the samara of the maple, or furnished with a feathery down like the dandelion.

16. **Flowerless Plants** are reproduced in several ways; the larger and more conspicuous produce spores which differ from seeds in that they contain no embryo of a new plant, but are merely cells which may develop and grow. Spores are very much smaller than seeds and may be wafted on the winds like dust. Some flowerless plants have no spores, but are reproduced from the parent plant, which divides into several parts, each of which develops into a new plant.

Puff-ball, emitting Cloud of Spores.

17. Flowering plants are again divided into the following classes, which, in turn, are subdivided into families, genera, and species. About a hundred thousand species have been described.

18. The **Polypetalæ** include the most highly organized plants. The flowers consist of many petals. The rose family, the pink family, the bean and pea family, are familiar examples.

The Wild Rose.

The Morning-Glory.

19. The **Gamopetalæ** have the petals united in a tube, or, in other words, have but a single petal. The morning-glory, the mints of all kinds, and plants with trumpet-shaped flowers may be cited as typical specimens.

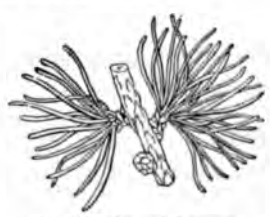
20. The **Apetalæ** have inconspicuous flowers without petals; many of the trees of the Temperate Zone, such as the oak and the elm, belong to this class.

The plants of the three classes mentioned above have net-veined leaves, and are of every size from large trees to humble shrubs and herbs. All of them are **Exogens** (outside growers), or plants whose stems increase in size by forming outside layers; all such plants have a true bark.

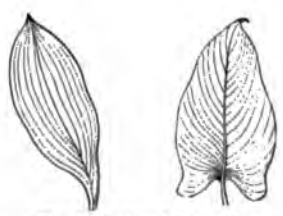
21. The **Gymnosperms** include the pines, firs, and other cone-bearing trees, and also certain low shrubs.

They are exogens, and have needle-shaped or fork-veined leaves. Those belonging to the temperate climate are evergreen, and the leaves are needle-shaped—or, at least, very small and narrow; but the Japanese ginko has broad, fork-veined leaves. The Welwitschia of Western Africa belongs to this class, and is one of the most extraordinary of plants; it lives to a great age, and the trunk may attain the diameter of a foot, although less than 2 feet high. The plant throughout its life has but two leaves, which sometimes increase to a length of 12 or more feet.

Net-veined Leaf.



Needle-shaped Leaves.

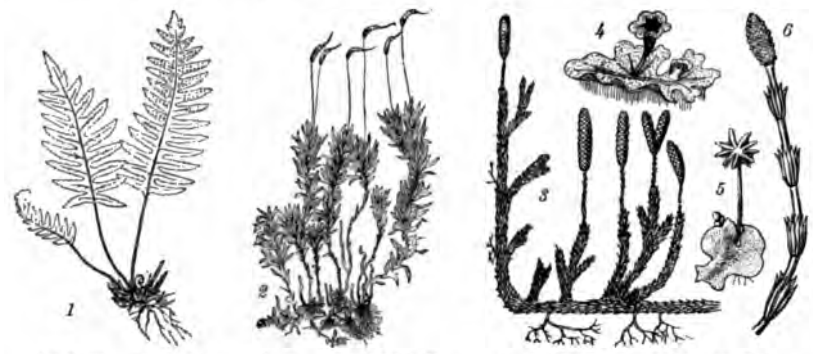


Parallel-veined Leaves.

22. The **Endogens** (or inside growers) include plants having parallel-veined leaves and a different mode of growth from the exogens. To this class belong the palms, the lilies, all the grasses, the cultivated grains, and the bamboos. There are many species, the most of which have simple stems without branches. Even the palms, almost the only trees belonging to this class, rarely have branches.

23. The **Cryptogamia** include a considerable number of classes which are less closely related to one another in their structure, in their aspects, and in their habits of life than are the different classes of the flowering plants. Some are green and purify the air as do flowering plants; some are of various colors other than green and live upon decaying or putrescent matter.

24. Among the many orders and families of green cryptogams are the **Filices,** or ferns, which produce spores on the under side of their leaves. These leaves—or fronds, as they are called in Botany—are of great variety of form and often of exquisite beauty. Ferns are most abundant in warm and moist countries, and in some tropical climates they attain the height of trees.



(1) *Fern.* (2) *A Common Moss.* (3) *A Club-Moss.* (4, 5) *Liverworts.* (6) *Marestail.*

Filices and Musci.

25. The **Musci,** or mosses, are minute green plants, often of exceeding beauty of structure, and are found most abundantly in cool, moist climates, and particularly in mountainous countries. Club-mosses, liverworts, and marestails are other orders belonging to this group.

26. The **Thallogens** include a great variety of organisms having very different modes of growth. The **Algæ,** which include all the sea-weeds and certain small aquatic plants in fresh water, and the **Lichens,** which flourish on rocks even amid the perpetual snows of the high mountains of Arctic regions, but which become dry and appear to be dead during protracted droughts, belong to this class.

(1, 2) *Common forms of salt-water Algæ.* (3) *Sea-weed.* (4, 5, 6) *Lichens.* (7, 8) *Mushrooms.*

Thallogens and Fungi.

27. The **Fungi** include many orders of plants having no green substance. Some of them live on dead or decaying organic matter; others are parasitic and subsist on other living organisms. Of the former, mushrooms, toadstools, and puff-balls are the most familiar examples. Many are microscopic in size, and some of those which are parasitic produce disease in other plants or animals, or even in man.

28. The **Protophytes** are the simplest of all organisms, consisting of but a simple cell endowed with life. The individuals divide, and thus the species are continued. To this class belong the *various* forms of bacteria and yeast plants.

29. The classification of animals is more difficult than that of plants, because they are more varied and the characteristics are more complicated. While naturalists are as well agreed regarding the species and genera of animals as they are regarding those of plants, there is less agreement as to the general grouping of the families into classes.

For the student of Physical Geography the animal kingdom may be ranged into eight great branches, these in turn divided into classes and orders, and these into families, genera, and species. The following scheme illustrates the method:

Branch.	Class.	Order.
Animal Kingdom. — Vertebrata.	Mammalia.	Bimana (*Man*).
		Quadrumana (*Monkey*).
		Carnivora (*Flesh-Eaters*).
		Herbivora (*Plant-Eaters*).
		Cetacea (*Whales*).
		Cheiroptera (*Bats*).
		Insectivora (*Insect-Eaters*).
		Rodentia (*Gnawers*).
		Edentata (*Toothless*).
		Marsupialia (*Pouched*).
		Monotremata (*Duck-Bills*).
	Aves.	
	Reptilia.	
	Batrachia.	
	Pisces.	
	Marsipobranchii.	
	Leptocardii.	
Arthropoda.		
Mollusca.		
Vermes.		
Echinodermata.		
Cœlenterata.		
Porifera.		
Protozoa.		

Only a single branch and a single class are carried out in this illustration. A complete scheme, with all the classes and orders, would require many pages, and belongs rather to the science of Zoology.

30. The highest branch of the animal kingdom is the **Vertebrata** (animals with a backbone), and at the head of the vertebrates, both in structure and in intelligence, are the mammals.

31. The **Mammalia** consist of warm-blooded and air-breathing animals; by far the larger portion of them live upon the land, and as a rule they are clothed with hair. All have to be nourished by the mother when young.

The species belonging to orders below the mammals are hatched from eggs or are produced by division, and the young, as a rule, seek their food, independent of the parent, as soon as they are hatched.

32. The class of **Aves,** or birds, is next below that of mammals. The birds are clothed with feathers, as a rule have powers of flight in the air, and are warm-blooded. A few of the species, like the penguin, the ostrich, and the apteryx, cannot fly, but the vast majority can, and some make flights of immense distances.

33. Next below the birds comes the class of **Reptilia,** which includes snakes, lizards, turtles, etc. They are variously covered, some with skin, some with scales, and others with a horny shell. Reptiles are air-breathing, cold-blooded animals and live mostly on land, although some are amphibious. Crocodiles and alligators are the largest of lizards. Among the serpents some are venomous, as are the rattlesnake of America, the viper of Europe, and the cobra of India.

34. Next lower comes the class of **Batrachia,** which includes the frogs, toads, etc.—cold-blooded creatures which undergo a remarkable metamorphosis during their growth. Frogs and toads hatch from eggs into tadpoles, which live entirely in the water, are without legs, breathe by gills, like fishes, and eat vegetables or decaying animal matter. After a time they lose their tails, and legs and lungs are developed; they leave the water and become land or amphibious animals, living upon insects or similar food.

35. The class of **Pisces** includes all the vast number of true fishes; they are cold-blooded, live entirely in water, and breathe by gills. There is a great number of families and genera. Fishes appeared on earth before the higher vertebrates. (See p. 15, par. 25.)

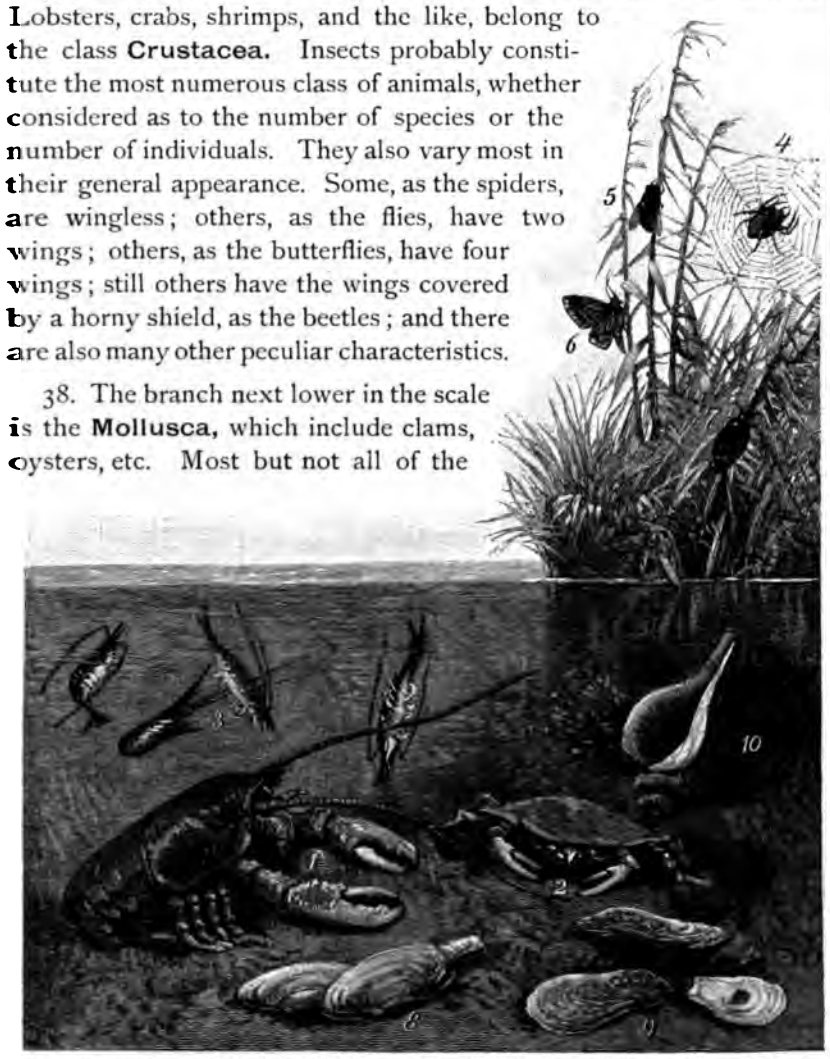
There are two other classes of vertebrates, which need not here be described.

To illustrate the division of orders into families the **Herbivora** may be selected. To this order belong more than a dozen families, of which the following are familiar examples. The **Suidæ**, or hog family, embrace the true swine, the wart-hog of Africa, and the peccaries of America. The **Cervidæ**, or deer family, include the genera of moose, elk, reindeer, deer, etc., all of which have solid branching horns. The **Ruminant** family includes oxen, buffaloes, musk-oxen, sheep, antelopes, etc., all having hollow horns.

36. The preceding families, orders, and classes belong to the highest branch of the animal kingdom, but by far the greater part of the animal creation, both in number of species and in number of individuals, belongs to the branches below the vertebrates. Only a brief mention can be made of these other branches.

37. The **Arthropoda** comprise the crustaceans and insects. Lobsters, crabs, shrimps, and the like, belong to the class **Crustacea.** Insects probably constitute the most numerous class of animals, whether considered as to the number of species or the number of individuals. They also vary most in their general appearance. Some, as the spiders, are wingless; others, as the flies, have two wings; others, as the butterflies, have four wings; still others have the wings covered by a horny shield, as the beetles; and there are also many other peculiar characteristics.

38. The branch next lower in the scale is the **Mollusca,** which include clams, oysters, etc. Most but not all of the species are covered with shells composed of carbonate of lime. Many sea-shells, particularly such as grow in salt water and in hot climates, have great beauty of form and brilliancy of coloring. The mollusks form an important item of food for both savage and civilized man. The most important in this respect are the various species of oysters.

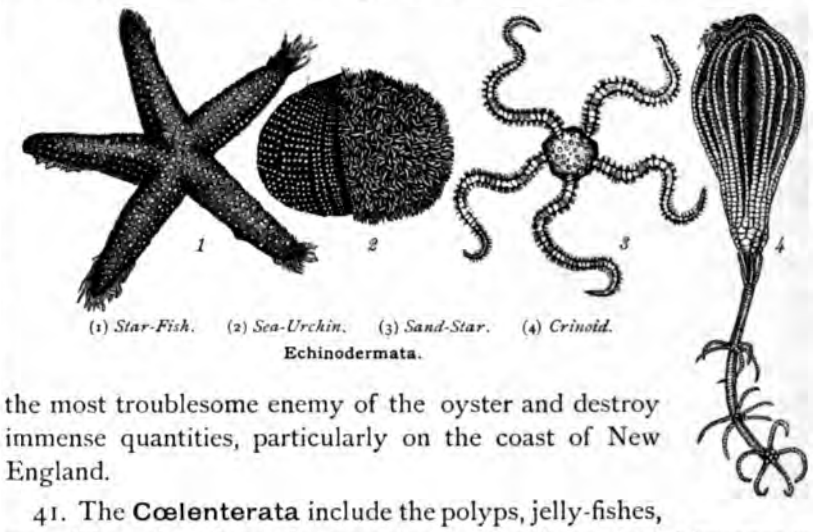


(1) *Lobster.* (2) *Crab.* (3) *Shrimp.* (4) *Spider.* (5) *Fly.* (6) *Butterfly.* (7) *Beetle.* (8) *Clam.* (9) *Oyster.* (10) *Periwinkle.*

Arthropoda and Mollusca.

39. The **Vermes** include the worms, of which there are about a dozen classes and many species. They play an important part in the economy of nature, but need not be further considered here.

40. The **Echinodermata** include the star-fishes, sea-urchins, crinoids, etc., all of them aquatic creatures. The star-fishes are the most troublesome enemy of the oyster and destroy immense quantities, particularly on the coast of New England.



(1) *Star-Fish.* (2) *Sea-Urchin.* (3) *Sand-Star.* (4) *Crinoid.*

Echinodermata.

41. The **Cœlenterata** include the polyps, jelly-fishes, etc. The polyps have the most interest for the geologist because to this class belong the coral-producing animals. (See p. 42, par. 39.) The sea-anemone belongs to this class. The jelly-fishes are soft creatures of jelly-like consistency, without any hard parts; and when they die, they rapidly decay and leave scarcely a trace behind.

42. The **Porifera** include all sponges. The sponges of commerce are the dried remains of about half a dozen species which come mostly from the Mediterranean and the West Indies. There are many species belonging to the Porifera inhabiting both fresh and salt water, but most of them are known only to the naturalist.

(1) *Coral Polyps.* (2) *Sea-Anemones.* (3) *Jelly-Fish.* (4) *Sponge.*

Cœlenterata and Porifera.

43. The **Protozoa** are at the very base of the animal kingdom. Most of the species of this class are minute, some of them consisting of but a single cell, to be detected only by the microscope. The **Infusoria** form one of the classes of this branch. They are the microscopic animals that swarm in decaying animal or vegetable infusions.

Questions.—What are organisms? How do they differ from minerals? To what three laws are they subject? What is heredity? Nutrition? What are some of its essentials? What is the law of variation? What is environment? Into what two great classes are organisms divided? What are flora and fauna? What is the starting-point in classifying organisms? What three theories are held regarding the origin of species? What is a genus? How are genera grouped? Into what two great classes are plants divided? What is the characteristic feature of flowering plants? What are exogens? Polypetalæ? Gamopetalæ? Apetalæ? Gymnosperms? What are endogens? How are flowerless plants reproduced? Describe the Filices. Musci. Algæ. Lichens. Fungi. Protophytes. What is the highest branch of the animal kingdom? Describe the Mammalia. Aves. Reptiles. Batrachia. Pisces. Arthropoda. Mollusca. Vermes. Echinodermata. Cœlenterata. Porifera. Protozoa. Infusoria.

II. The Distribution of Life with Reference to Abundance.

44. It is a very familiar fact that life is much more abundant in some places than in others. Some of the causes of this are readily obvious. It is clear that—with plants, at least—the growth is most luxuriant in a warm climate with ample rain and on a fertile soil. Closer study shows that everything which affects life at all affects its abundance—that is, its abundance depends upon the environment—and naturally life is most plentiful where all the conditions are most favorable, and it diminishes in quantity as the conditions become less auspicious.

Only in exceptional regions do the conditions become so unfavorable that there is utter barrenness or desolation, with absolutely no life. Between these extremes of abundance and sterility there is every gradation.

The vegetation constitutes a much more important feature in the aspects of a landscape than does the animal life, and it is for several reasons of much more geographical interest. The more obvious causes of dissimilarity in the abundance and aspects of vegetation in different places are the relative amounts of heat and rainfall. These will, therefore, be first considered, and then other causes or conditions which affect the abundance of vegetation; for where vegetation is most profuse and most constant, there will animal life be most abundant also.

45. **The Equatorial Belt.**—Vegetable growth is most rapid and luxuriant where the temperature is between 70° and 90°, where there are neither great extremes nor sudden changes in temperature, and where there is sufficient moisture.

Hence life is most abundant near the equator, where there is perpetual summer and where there is a belt of rains all around the globe. Here are found the richest forest-growths and the densest jungles. In this belt are the luxuriant forests of Brazil, of Central Africa, and of the East Indian Islands. Both on the land and in the sea there are, as a rule, the greatest abundance and variety of life. On the land the flora and the fauna are composed of the greatest number of species, and large plants, quadrupeds, birds, reptiles, and insects are most numerous.

There is, too, a greater profusion of life in tropical seas, particularly near the warm surface, than in the colder parts of the ocean. It is in warm and sunny waters only that the coral-polyps flourish in such countless myriads that their dead bodies form great islands and reefs.

Recent investigations prove that minute forms of animal life float near the surface of these tropical seas in quantities amounting in weight to many tons per square mile. Their dead carcasses, sinking, furnish food to the animals which live in the cold waters at the bottom, while their shells and skeletons form thick strata on the ocean's bed.

46. **The Polar Regions.**—The other extreme is found in the perpetual cold of the polar regions. Growth is slow at temperatures below 50° and ceases entirely at 32°. Indeed, most species of plants are killed outright by freezing, and the vast majority of species of animal life cannot survive in air or in water below 32°.

In the polar regions, owing to the absence of heat, is found the greatest desolation on earth; so desolate are these frigid wastes that man himself has not yet been able to reach the pole. Only herbs and shrubs but a few inches high or lichens and mosses of low orders of growth exist in those cold solitudes, while in the most northern lands reached by man there is but a scanty vegetation of even these humble plants growing during the short summer. There are correspondingly few land animals; birds which can roam far and wide in search of food and which can seek a more genial climate for the long winter, or fishes in the sea (for the water never freezes to the bottom, and therefore does not become colder than 26°), and the few amphibious animals which get their food from the sea, constitute nearly the whole fauna.

So, too, in the midst of the perpetual snow and ice and in the thin air on the tops of lofty mountains there is but scanty life at best, and sometimes none at all.

47. **The Temperate Zones.**—Between the tropics and the polar circles there are greater differences as to the abundance of life than are found in either the hotter or the colder regions. In the Temperate Zones there is a summer of sufficient length and heat for luxuriant vegetation, and the variations in the quantity of life existing in different regions are due more to the rainfall and uniformity of climate than to the heat.

There are some places in temperate climates where the actual amount of vegetation per acre or per square mile is probably as great as that to be found upon an equal area in any portion of the dense and luxuriant forests of the tropics, but the growth has been much slower and it represents a much longer period of accumulation.

48. A somewhat uniform climate is essential to an abundance of life. Certain species are destroyed either by extreme heat or by severe cold, and regions subject to a great range of temperature exhibit a paucity of life when compared with other regions having the same average temperature, but a more uniform climate. Excessive droughts also destroy many species, even though in ordinary years the conditions are all favorable.

These several causes and various contrasts of climate exhibit their effects on tree life more than they do in the career of the smaller and short-lived species, and they give that wonderful variety to the aspect of landscapes in the different regions of the Temperate Zone which is lacking in either the tropical or the polar regions.

49. **Forests** occur naturally where there is a certain combination of several favorable conditions. They require abundant rain every year, a somewhat uniform climate, with droughts never prolonged more than a few months at most, a warm or moderately warm temperature—at least, in summer—soil of sufficient fertility and of a proper mechanical texture, in connection with several other less obvious conditions.

Forests flourish in greatest luxuriance in the equatorial belt, where a high temperature, a uniform climate, and much rain are found, and in the North Temperate Zone on the western slopes of mountains and in those hilly regions that are abundantly supplied with rain.

The most extensive forests of the globe are those of South America, those of Eastern North America, of the western slopes of the mountains of Western North America, of the rainy region of Central Africa, and of the mountain-region of Central Europe and of Siberia.

50. **Treeless Regions** exist in all the continents, and have a great variety of aspect because they occur in various climates and are due to many causes.

The polar regions are treeless because of the cold; most deserts are treeless because of the absence of rain; some because of salt in the soil. Annual fires may kill the young trees; animals or insects may destroy the seed or the seedling; dense sod or the texture of the soil may be unfavorable for the lodgment and germination of the seed; and so through a curious variety of causes many portions of the globe remain destitute of forests.

Consequently, in nature some treeless regions are simply barren deserts; others fertile and grassy, as are the prairies of Illinois; others green only during the wet and growing portions of the year, as are the plains of Central California and the savannas of South America. The tundras of Siberia are treeless frozen swamps thawing only to a slight depth in summer.

51. There are also regions which are neither covered with forests nor treeless, but in which there are some trees, though not enough to constitute a forest. These too have a great variety of aspect and are dependent upon various causes.

Some of these tracts are very fertile and have scattered trees of but one or two species. Interspersed in the landscape, they often add greatly to its beauty, as in some of the fertile valleys of California and Oregon. In some regions otherwise treeless copses are formed here and there, like the "cross-timber" in Texas.

Other tracts of this kind occur along the borders between the treeless and forest regions, where the natural conditions which produce forests or prevent them are so evenly balanced that some slight difference, such as a little more gravel in the soil or a little more moisture, will turn the scale one way or another. Such is the case with many of the patches of woodland and "openings" in the great prairie-region from Indiana to Minnesota and along its margin.

52. In many regions, particularly in the North Temperate Zone, the conditions necessary for the maintenance or prevention of forests are so evenly balanced that man can control their existence or their absence.

Lands originally treeless can often be covered with forests by planting carefully-chosen species and caring for the young trees until they are large enough to overcome the natural obstacles. On the other hand, in many cases, forests once destroyed by man do not without artificial aid again grow and clothe the land. Such is the case with great areas in the North Temperate Zone; much of the agricultural land of both Europe and America once forest-clad is now cleared and subdued by man and kept so for his use.

53. Trees grow on mountains and on hills more readily than on plains. Great mountain-chains have heavy forests on their sides, and the smaller mountains and isolated hills rising from treeless plains and deserts in the dry interior of the continents have usually scattered trees, becoming dense enough here and there to constitute patches of forest.

On the plateaus of the Temperate Zones the trees are, as a rule, too much scattered to constitute forests; or when forests exist, they are more open than those of lower lands.

Some regions too dry for forests have an abundant shrubby vegetation, the larger individuals here and there growing to the size of small trees.

The dense growth of low under-shrubs, called heather, on the plains of Northern Europe constitute the *heaths*, while the dense growth of larger shrubs in America, more particularly in Mexico and the Western United States, constitutes *chaparral*. Similar dense shrubby vegetation in Australia is called *scrub*.

54. **Deserts.**—Strictly speaking, any barren, unproductive place is a desert; but in Geography the term is more especially applied to dry regions which are barren because of lack of water.

Any region, no matter how fertile may be the soil or how genial the climate, is a desert if there be no water. Without water there can be no vegetable growth, and without vegetation no animal life. With a scanty supply of water there may be a sparse vegetation and a correspondingly limited development of animal life; such is the condition of most of the interior basins.

In fact, lands range in fertility and productiveness through every grade from the most luxuriant forests and prairies to the most barren wastes.

The great sterile regions in the interior of each of the continents are caused by the lack of rain. It is a popular error that they are barren because they have a sandy soil. As a matter of fact, there is every kind of soil. It is sometimes sandy, sometimes rocky, and often of great fertility. Some of the most fertile, beautiful, and densely-populated regions of the earth are artificial oases in desert or partly desert countries, but made fertile and fruitful by artificial irrigation.

55. **Light and Darkness.**—Light is essential to the life and growth of most organisms; only low forms can exist without it. As has been stated, all green plants require light. All the aquatic plants and seaweeds are found only at or near the surface, and most of the fishes and the higher forms of animal life in the sea exist in water not exceeding 100 fathoms in depth.

Besides this surface or *pelagic* life, there is much animal life in the perpetual darkness and in the cold waters at the bottom of the ocean. This is called *abysmal* life, and the food for these submarine creatures consists of the dead material which falls from the surface. In the deep sea, therefore, life is most abundant near the top and on the ocean-bed; in the intermediate depths it is less plentiful.

Of the many species of animal life living on the ocean's floor, all are low in the scale of being; even those highest in the scale are frequently blind, and many are without eyes. There are, too, blind and eyeless insects and fishes in the perpetual darkness of the Mammoth Cave and some other caverns.

There is no vegetable life known in the darkness of deep waters, but in deep mines and caverns fungi grow on decaying timbers or other decaying organic matter which may chance to find its way there.

The food of the organisms which live and grow in darkness, whether in caverns on land or in the depths of the sea, is produced primarily in the light. The sun's light as well as the sun's heat is an essential factor in the existence of life on the globe.

The desolation of the polar regions is intensified by the darkness of the long winter night. On the other hand, in the light of the long summer day the vegetation of high latitudes grows and ripens in its very short summer.

56. **Heights and Depths.**—Considered in respect to altitude, the greatest abundance of life is within a few hundred feet of the level of the sea. It diminishes with the ascent into the air or the descent into the waters. The diminution is not regular, but it may be stated as a general fact that plateaus are less productive than high plains, and these less productive than low plains and valleys. This, on the land, is largely dependent upon temperature and moisture, but there are other causes which contribute to the result.

57. **Abundance is not always Variety.**—The abundance of life in any region is not to be confounded with the number of species inhabiting it. There may be a very luxuriant growth of vegetation composed of comparatively few species, and again there may be a sparse or thin vegetation consisting of many species.

For example, some of the forests of Oregon and Washington, consisting essentially of less than a dozen species, grow in such grand proportions that if the wood were cut and piled on the land it would cover it to the depth of 10 or 15 feet; while, on the other hand, there are regions in South Africa in which several thousand species may be found by botanists, but where vegetation is usually so sparse that if all the species of plants, taken together, were cut and distributed over the land, the whole amount would not cover it to the depth of half a dozen inches.

58. The **Distribution of Life** in relation to time has already been considered in connection with the history of the strata and the geological eras (pp. 13–16). Reference is made to it again because the history of life in the past is closely related to the distribution of species at present.

In the history of the planet, when life appeared there were at first comparatively few species; these all belonged to the lower forms (see p. 14, par. 20), and the same or very similar species were widely distributed over the earth. As time went on new species came into existence in succession, and there was gradual progress toward more highly developed forms.

In the Tertiary Age the continents had assumed somewhat the conditions in which they now appear (see p. 16, par. 27), and many animals and plants similar to those now living—some of them, probably, identically the same—were in existence. What is of especial interest to the student of Physical Geography is that the present distribution of continents and oceans was then much as it is now, and that the present distribution of species on the globe is very closely related to the extinct kinds belonging to the Tertiary Age which are found fossil in various countries.

Questions.—Upon what does the abundance of life depend? Which forms the more important feature in a landscape, the vegetation or the animal life? Where is vegetation most luxuriant? In what seas is animal life most abundant? In what regions does the greatest scarcity prevail? Where does the abundance vary most? What conditions are essential to abundant distribution of life? Where are forests found? Treeless regions? Are all tracts necessarily forests or treeless? How does man control the growth or absence of forests? How do the different forms of relief affect the growth of trees? What is a heath? What is chaparral? What is a desert? Why is its soil barren? How is the abundance of life affected by light and darkness? By heights and depths? Is abundance always variety? What were the conditions of life in the early geological ages?

II. The Distribution of Life with Reference to Abundance.

44. It is a very familiar fact that life is much more abundant in some places than in others. Some of the causes of this are readily obvious. It is clear that—with plants, at least—the growth is most luxuriant in a warm climate with ample rain and on a fertile soil. Closer study shows that everything which affects life at all affects its abundance—that is, its abundance depends upon the environment—and naturally life is most plentiful where all the conditions are most favorable, and it diminishes in quantity as the conditions become less auspicious.

Only in exceptional regions do the conditions become so unfavorable that there is utter barrenness or desolation, with absolutely no life. Between these extremes of abundance and sterility there is every gradation.

The vegetation constitutes a much more important feature in the aspects of a landscape than does the animal life, and it is for several reasons of much more geographical interest. The more obvious causes of dissimilarity in the abundance and aspects of vegetation in different places are the relative amounts of heat and rainfall. These will, therefore, be first considered, and then other causes or conditions which affect the abundance of vegetation; for where vegetation is most profuse and most constant, there will animal life be most abundant also.

45. **The Equatorial Belt.**—Vegetable growth is most rapid and luxuriant where the temperature is between 70° and 90°, where there are neither great extremes nor sudden changes in temperature, and where there is sufficient moisture.

Hence life is most abundant near the equator, where there is perpetual summer and where there is a belt of rains all around the globe. Here are found the richest forest-growths and the densest jungles. In this belt are the luxuriant forests of Brazil, of Central Africa, and of the East Indian Islands. Both on the land and in the sea there are, as a rule, the greatest abundance and variety of life. On the land the flora and the fauna are composed of the greatest number of species, and large plants, quadrupeds, birds, reptiles, and insects are most numerous.

There is, too, a greater profusion of life in tropical seas, particularly near the warm surface, than in the colder parts of the ocean. It is in warm and sunny waters only that the coral-polyps flourish in such countless myriads that their dead bodies form great islands and reefs.

Recent investigations prove that minute forms of animal life float near the surface of these tropical seas in quantities amounting in weight to many tons per square mile. Their dead carcasses, sinking, furnish food to the animals which live in the cold waters at the bottom, while their shells and skeletons form thick strata on the ocean's bed.

46. **The Polar Regions.**—The other extreme is found in the perpetual cold of the polar regions. Growth is slow at temperatures below 50° and ceases entirely at 32°. Indeed, most species of plants are killed outright by freezing, and the vast majority of species of animal life cannot survive in air or in water below 32°.

In the polar regions, owing to the absence of heat, is found the greatest desolation on earth; so desolate are these frigid wastes that man himself has not yet been able to reach the pole. Only herbs and shrubs but a few inches high or lichens and mosses of low orders of growth exist in those cold solitudes, while in the most northern lands reached by man there is but a scanty vegetation of even these humble plants growing during the short summer. There are correspondingly few land animals; birds which can roam far and wide in search of food and which can seek a more genial climate for the long winter, or fishes in the sea (for the water never freezes to the bottom, and therefore does not become colder than 26°), and the few amphibious animals which get their food from the sea, constitute nearly the whole fauna.

So, too, in the midst of the perpetual snow and ice and in the thin air on the *tops of lofty* mountains there is but scanty life at best, and sometimes none at all.

47. **The Temperate Zones.**—Between the tropics and the polar circles there are greater differences as to the abundance of life than are found in either the hotter or the colder regions. In the Temperate Zones there is a summer of sufficient length and heat for luxuriant vegetation, and the variations in the quantity of life existing in different regions are due more to the rainfall and uniformity of climate than to the heat.

There are some places in temperate climates where the actual amount of vegetation per acre or per square mile is probably as great as that to be found upon an equal area in any portion of the dense and luxuriant forests of the tropics, but the growth has been much slower and it represents a much longer period of accumulation.

48. A somewhat uniform climate is essential to an abundance of life. Certain species are destroyed either by extreme heat or by severe cold, and regions subject to a great range of temperature exhibit a paucity of life when compared with other regions having the same average temperature, but a more uniform climate. Excessive droughts also destroy many species, even though in ordinary years the conditions are all favorable.

These several causes and various contrasts of climate exhibit their effects on tree life more than they do in the career of the smaller and short-lived species, and they give that wonderful variety to the aspect of landscapes in the different regions of the Temperate Zone which is lacking in either the tropical or the polar regions.

49. **Forests** occur naturally where there is a certain combination of several favorable conditions. They require abundant rain every year, a somewhat uniform climate, with droughts never prolonged more than a few months at most, a warm or moderately warm temperature—at least, in summer—soil of sufficient fertility and of a proper mechanical texture, in connection with several other less obvious conditions.

Forests flourish in greatest luxuriance in the equatorial belt, where a high temperature, a uniform climate, and much rain are found, and in the North Temperate Zone on the western slopes of mountains and in those hilly regions that are abundantly supplied with rain.

The most extensive forests of the globe are those of South America, those of Eastern North America, of the western slopes of the mountains of Western North America, of the rainy region of Central Africa, and of the mountain-region of Central Europe and of Siberia.

50. **Treeless Regions** exist in all the continents, and have a great variety of aspect because they occur in various climates and are due to many causes.

The polar regions are treeless because of the cold; most deserts are treeless because of the absence of rain; some because of salt in the soil. Annual fires may kill the young trees; animals or insects may destroy the seed or the seedling; dense sod or the texture of the soil may be unfavorable for the lodgment and germination of the seed; and so through a curious variety of causes many portions of the globe remain destitute of forests.

Consequently, in nature some treeless regions are simply barren deserts; others fertile and grassy, as are the prairies of Illinois; others green only during the wet and growing portions of the year, as are the plains of Central California and the savannas of South America. The tundras of Siberia are treeless frozen swamps thawing only to a slight depth in summer.

51. There are also regions which are neither covered with forests nor treeless, but in which there are some trees, though not enough to constitute a forest. These too have a great variety of aspect and are dependent upon various causes.

Some of these tracts are very fertile and have scattered trees of but one or two species. Interspersed in the landscape, they often add greatly to its beauty, as in some of the fertile valleys of California and Oregon. In some regions otherwise treeless copses are formed here and there, like the "cross-timber" in Texas.

Other tracts of this kind occur along the borders between the treeless and forest regions, where the natural conditions which produce forests or prevent them are so evenly balanced that some slight difference, such as a little more gravel in the soil or a little more moisture, will turn the scale one way or another. Such is the case with many of the patches of woodland and "openings" in the great prairie-region from Indiana to Minnesota and along its margin.

52. In many regions, particularly in the North Temperate Zone, the conditions necessary for the maintenance or prevention of forests are so evenly balanced that man can control their existence or their absence.

Lands originally treeless can often be covered with forests by planting carefully-chosen species and caring for the young trees until they are large enough to overcome the natural obstacles. On the other hand, in many cases, forests once destroyed by man do not without artificial aid again grow and clothe the land. Such is the case with great areas in the North Temperate Zone; much of the agricultural land of both Europe and America once forest-clad is now cleared and subdued by man and kept so for his use.

53. Trees grow on mountains and on hills more readily than on plains. Great mountain-chains have heavy forests on their sides, and the smaller mountains and isolated hills rising from treeless plains and deserts in the dry interior of the continents have usually scattered trees, becoming dense enough here and there to constitute patches of forest.

On the plateaus of the Temperate Zones the trees are, as a rule, too much scattered to constitute forests; or when forests exist, they are more open than those of lower lands.

Some regions too dry for forests have an abundant shrubby vegetation, the larger individuals here and there growing to the size of small trees.

The dense growth of low under-shrubs, called heather, on the plains of Northern Europe constitute the *heaths*, while the dense growth of larger shrubs in America, more particularly in Mexico and the Western United States, constitutes *chaparral*. Similar dense shrubby vegetation in Australia is called *scrub*.

54. **Deserts.**—Strictly speaking, any barren, unproductive place is a desert; but in Geography the term is more especially applied to dry regions which are barren because of lack of water.

Any region, no matter how fertile may be the soil or how genial the climate, is a desert if there be no water. Without water there can be no vegetable growth, and without vegetation no animal life. With a scanty supply of water there may be a sparse vegetation and a correspondingly limited development of animal life; such is the condition of most of the interior basins.

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IV. Distribution of Life with Reference to Kind.

59. The same kinds of animals and plants are not found everywhere. Ordinary observation reveals the fact that the native productions of each climate and of each country are unlike those of other climates and of other countries.

The natural distribution of the various species both of plants and of animals over the globe is governed by two sets of causes.

The first cause is the local environment, more especially the climate: oranges do not grow in Greenland, nor are reindeer found in Florida. The second cause is the origin and migration of the species themselves, for nature does not stock each region with all the creatures capable of living in it.

Organisms must be adapted to the countries they inhabit, but every organism does not necessarily reach every country suited to it. Plants native of only one country, when carried to other and new countries, often become there weeds and take possession of the soil, crowding out the indigenous plants. Foreign birds, animals, and even insects, carried to new countries sometimes crowd out or exterminate the natives, or so destroy certain kinds of native vegetation as to change the natural condition and appearance of the region.

All the theories relating to the origin of species recognize the fact that their present distribution is to be accounted for only by assuming their migration and spread from the place of their origin. Mountains, seas, deserts, climate, and all other geographical features which have promoted or hindered such migration, have affected the natural distribution of species.

60. The department of Physical Geography which treats of the distribution of those kinds of plants which impart a special aspect to the landscape and which are useful to man is called **Botanical Geography,** and that which treats of the more conspicuous and useful animals is called **Zoological Geography.** The former is of most interest to the general student.

61. **The Duration of the Life of Plants.**—In considering the geographical characteristics of vegetation it is well to consider certain features of plants other than their botanical classification. It is useful to group them according to the duration of their lives, for this is intimately related to the climate they may inhabit.

62. Some species live but a single year or season, and are therefore called **Annual Plants.** They spring up from seed which ripened during some previous year, grow, flower, and ripen a new crop of seed all in a single growing season, and then die. Such plants have soft stems and are popularly called **Herbs.**

Annual plants are most abundant in those temperate climates which have a winter cold enough to stop all growth and a summer long and warm enough for the plant to mature, and in those hot climates which have a productive rainy season succeeded by a drought long enough to render the soil dry and to stop vegetable growth. Numerous examples of annual plants might be given; they include most of the grains and many of the food-plants of temperate countries.

63. Species which live but two years are called **Biennial Plants.** During the first year a plant of this kind accomplishes a large part of its growth, and nutriment is stored up in the root for use the next year. The stem is that of an herb and dies down to the ground when the season of growth ceases, the root remaining alive through the winter. During the second year it produces a more vigorous growth and then flowers and ripens its seed, after which the whole plant dies.

Turnips are familiar cultivated food-plants belonging to this group. Biennial plants are distributed over the globe much as annual plants are.

64. There are still other species, called **Perennial Herbs,** in *which the roots* live for an indefinite period, and from which there grows up each summer a crop of low herbaceous stems producing flowers and seeds, the stems dying down to the ground each year, but the roots living for many years.

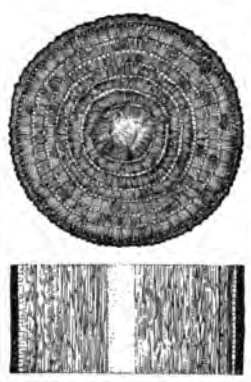
Asparagus, clover, and all those grasses which produce turf or a sod belong to this class. These species are most abundant in climates where the winters are long or in those hot climates where protracted droughts alternate with the shorter season of growth.

Heat or drought which is severe enough to check all vegetable growth produces effects similar to those of a cold winter with certain species. In temperate climates there is a suspension of growth during the winter because of cold; in many hot countries there is a similar suspension because of heat and drought. Gardeners are familiar with the fact that an artificial winter, so to speak, may be produced and plants be made to flower out of their natural season by drought as well as by cold.

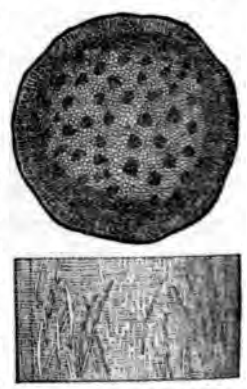
Where the stems of plants live more than one year they usually become woody. They always become woody in a climate which has winters or great droughts, and, as a rule, also in most tropical countries. Such plants may continue to grow for many years, increasing in size from year to year and becoming trees. Others may extend in length only, and become long vines.

These classes or groups are not founded on the characteristics by which plants are classified for scientific study, although founded on peculiarities used by botanists in the description of particular species themselves. These several kinds (if kinds they may be called) play an important part in determining the aspect of vegetation.

65. **Exogens and Endogens.**—The grouping of all flowering plants into two great classes, the exogens and the endogens, is important to the geographer. The stems of woody exogens increase in size, as long as the plant continues to live, by adding some wood each growing season on the outside, just beneath the bark. In this way all the trees belonging to the temperate climate increase in size, and many of them attain a great age.



Sections of an Exogen.



Sections of an Endogen.

Many woody plants always remain small, and are called *shrubs.* Such as grow to a height of 30 or more feet are called *trees;* an assemblage of trees constitutes a *woodland* or *forest.*

Most exogens branch as they increase in size. All the trees and shrubs of temperate and cold climates are branching.

With endogens (or inside growers) the growth is from the interior, and after the stem attains a certain size it grows no larger in diameter, but simply increases in length. Palms belong to this class. The trunk does not increase in size materially after the tree is in the vigorous growth of its early life, but it grows higher from the bud which crowns the stalk, all of the foliage being umbrella-like and near the top, at which point the fruit also is produced.

Most endogens do not branch except at the ground. The ordinary grasses and grains are familiar examples of this fact on a small scale; the palms and bamboos exhibit the same fact on a larger scale.

The endogens of temperate and cool climates are mostly herbs but few feet in height at most; and when they produce any effect on the character of the landscape, it is by the massing of a great number of individuals growing together (as in the case of grasses) rather than by the prominence of particular individuals.

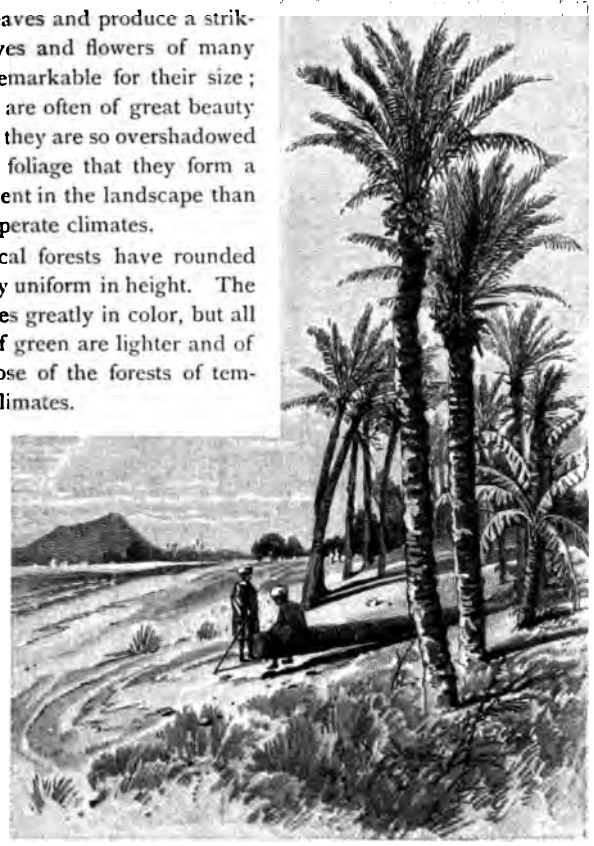
The endogens of hot climates, particularly in the tropics, attain a much greater size and often constitute trees, of which the palms are the most conspicuous examples. There are, however, many tall kinds. The bamboos are but gigantic grasses, and rattans, which are tropical vines belonging to the endogens and climbing on trees, sometimes grow to be more than 400 feet long.

66. **Climate.**—It has already been shown that the abundance of life is largely dependent upon climate, and it is also true that the peculiar appearance of vegetation, which is occasioned by the presence of certain kinds of plant-life, is due to the same cause.

67. **The Equatorial Belt.**—The greatest variety of species, as well as the greatest abundance, is found in the equatorial belt. The species of trees in the tropical forests outnumber those of other regions, and they remain green throughout the year.

Among the distinctive features of tropical vegetation, the palms, with their naked stems, widespread tops, and gigantic leaves, are particularly noticeable. Other endogens, such as the bamboo and the banana, have large leaves and produce a striking effect. The leaves and flowers of many tropical species are remarkable for their size; but, while the flowers are often of great beauty and of brilliant colors, they are so overshadowed by the luxuriance of foliage that they form a less conspicuous element in the landscape than do the flowers of temperate climates.

The trees of tropical forests have rounded heads and are roughly uniform in height. The foliage, however, varies greatly in color, but all of the many shades of green are lighter and of a bluer tone than those of the forests of temperate and of cold climates.



Palm Trees.

68. **The Temperate Zones.**—In temperate climates there is less variety of kind, but greater variety of aspect. A forest is composed of fewer species, but the different forests are more unlike one another in appearance. Some contain only broad-leaved trees, with spreading tops; these shed their foliage in autumn, and are called *deciduous*. Other forests are composed of evergreens of conical shape; still others of mixtures of these two in every variety of relative proportion.

The aspect of the forests of temperate climates changes entirely with the season of the year, particularly when there is a considerable proportion of deciduous trees. Leafless in winter, light green in spring, dark green in summer, succeeded by the colors of autumn, they produce a variety not found in the tropics. If evergreen, however, they are more uniform as to color than tropical forests.

In all regions with a moderate or scanty rainfall or with prolonged droughts, whether in a tropical climate or in a temperate climate with hot summers, there is a large proportion of shrubby vegetation. On rolling plains or on low hills the shrubs or bushes are usually scattered in detached clusters; on the mountain-sides they are more apt to form a dense growth of chaparral.

69. **The Polar Regions.**—In hot and temperate climates there are plants of every size, from the smallest shrubs to the largest trees, but it is not so in cold climates. In passing north or in ascending high mountains the forests usually cease somewhat abruptly.

In the polar regions the woody species are few and are mere shrubs, which become smaller as higher latitudes are reached, until at last they disappear entirely. The most common are willows and birches, which creep close to the ground, covering it like a mat.

The changes in the character of plant-life seen on ascending high mountains in the tropics are similar to those observed in going from the equator toward the poles. (See p. 92.) This is one of the features that give variety to the tropics, as in mountainous regions it is often possible to find within the range of a few miles changes similar to those which would be encountered in traveling over many degrees of latitude away from the equator.

70. The distinctive features of vegetation in the different regions of the globe are imparted by the presence of particular families and by modes of growth rather than by individual species, or even by particular genera.

Each species must, of course, be adapted to its climate, and this adaptation is often accompanied by striking peculiarities of form.

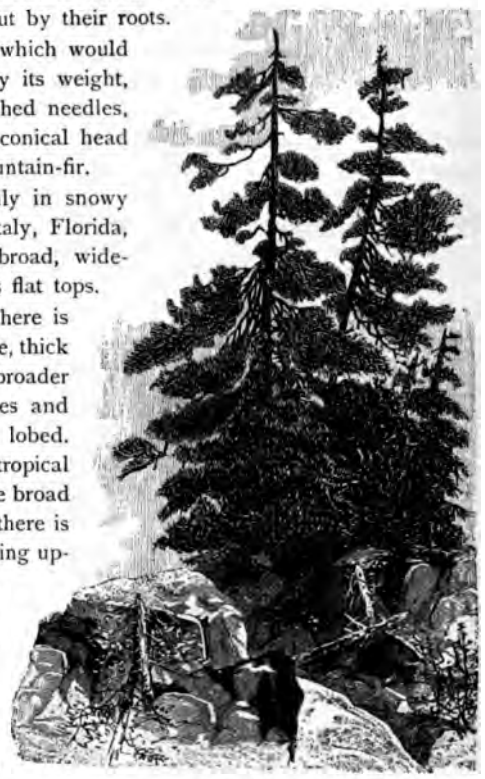
The palms, for example, are unlike any of the trees of temperate or cold climates. In the tropics most plants are green throughout the whole year, and, indeed, during their whole lives. Where there is no cold season to kill the foliage, the new leaves grow before the old ones fall. The term *evergreen* is not usually applied to the perpetual green of the tropics, but is used more especially for those trees and other plants of temperate and cold climates which remain green throughout the year amid other forms of vegetation which lose their verdure in winter.

The evergreen trees of cold climates represent the opposite extreme from the palms in aspect and growth. The leaves are reduced in width to mere needles, the trunk is greatest at the base, the branches are drooping, and the head of the tree is conical in shape. The form of each is an adaptation to the climate. The palm, with its simple, tough, elastic trunk, sways with the breeze and bends unharmed before the tropical hurricane which would tear the stronger pine and fir out by their roots.

The snow of colder regions, which would crush the umbrella-like palm by its weight, glides harmlessly from the polished needles, the drooping branches, and the conical head of the northern pine and the mountain-fir.

Trees have conical heads only in snowy climates. Even the pines in Italy, Florida, and other hot regions have broad, wide-spreading heads, and sometimes flat tops.

The plants of hot regions, if there is sufficient moisture, have, as a rule, thick and leathery leaves, which are broader than those of temperate climates and not so commonly notched or lobed. The peculiar characteristics of tropical vegetation are that the trees have broad heads or rounded outlines, that there is a great profusion of vines struggling upward through the dense forests toward the light, and that, upon the whole, the greater proportion of the flowers is yellow.



Pine Trees.

In the colder regions and where there are snows those of the trees which have broad leaves shed them in autumn before the snows come and put forth fresh leaves after the snows melt. These are the deciduous trees, already mentioned. Much the larger proportion of them have notched or lobed leaves and the predominating color of the flowers is blue.

The evergreens of snowy and cold climates belong to the natural order Coniferæ (or cone-bearing trees), to which belong the pines, firs, spruces, cedars, and similar species. They constitute great forests in the temperate zone and furnish the most abundant timber of the globe.

If regions are dry, no matter whether hot or temperate, the trees are smaller and fewer and the proportion of shrubs is greater. They are also more thorny, the leaves are smaller, and the wood, as a rule, is more brittle.

71. **Social and Solitary Species.**—The distribution of organisms is related to climate in still another way, which affects the aspects of nature in different climes. Some species both of plants and of animals are called *social* or *gregarious;* others are called *solitary*. Social species are those in which many individuals of the same kind live together. Forests may be composed of but a few, or even of a single, species of trees, and plains may be covered with grass of but few species, or even of a single prevailing kind. These are called *social plants*. Solitary species, in distinction, are those in which the individuals do not live together in large numbers for mutual aid or protection; they may be numerous in any region, but do not help one another in their competition with other species.

Because of the urgent need of mutual assistance, occasioned by the severity of the climate or the difficulty of obtaining a livelihood, social species are most common in temperate or cool countries.

In such regions are found forests of fir or beech or oak which, if not composed entirely of one species, have some one or two so prevailing as to give the landscape a corresponding character. It is, indeed, the rule that the forests of temperate climates consist of some one, two, or few species, which so prevail over the others as to give a distinctive character to the forests as a whole. So, too, in the fields the grasses of few species often form a sod or turf, covering the earth with a dense carpet in spring; the hillsides are often bright with the colors of social plants in flower at the same time. Broad areas are yellow with buttercups, orange with mariposas, or white with daisies, forming great masses of color.

The same rule applies in regard to animal life; the Temperate Zones are the native home of many species that roam in large herds or flocks. On the land herds of bison, antelope, and other herb-eating animals are found. In the seas are fishes which swarm in enormous shoals, as the cod, mackerel, herring, etc. In the air flights of pigeons sometimes darken the sun. Insects are also associated in great numbers; swarms of mosquitoes are found in one place and multitudes of locusts in another. These conditions extend to the colder, and even to the polar, regions. There, too, grasses form a sod and animals move in herds—smaller, to be sure, because of the greater difficulties in obtaining food. Fishes, too, swarm in shoals and birds nest in enormous numbers together on the crags.

But in tropical regions, where the climate is more uniform, and where the wants of life are more easily supplied, species, whether animal or vegetable, are, as a rule, more solitary, usually congregating in families rather than in great flocks or herds.

Grasses do not form a sod, and turf, so characteristic of our temperate climates, is practically unknown. Individual plants may be larger, as is the case with most of the tropical grasses; there may be a carpet of verdure, but not a grassy turf.

In the tropics the forests are made up of a large number of species, but it is rare that any one so predominates as to give a special character to the landscape. Looking down upon a forest in some tropical valley from a neighboring height, one sees a great variety and luxuriance of foliage, the trees rising in rounded outlines with great density of foliage. There are many forms of vegetation producing a general effect, but there is no one so prominent throughout as to give a peculiar character to the scene.

There are also various kinds of flowers. They may be found of striking forms, of gigantic size, of brilliant colors, of bewildering variety, and often of exquisite beauty, but, as a whole, they are less conspicuous objects in the landscape than the flowers of temperate climates. The species are less social, and the individual flowers, though they may be large and showy of themselves, are overshadowed by the rank, luxuriant growth of perennial green foliage. There is no such massing of color as is common in the Temperate Zones.

The rule applies to animal as well as to vegetable life, unless, perhaps, in the case of insects and of marine life. Many species of insects live only in colonies; of these the ant is a conspicuous example, and in the sea various low forms of life, such as the coral polyp, exist together in vast numbers; but the larger and higher animals either roam solitary, as the tapir and rhinoceros, or live in families, as do the monkeys.

72. **Cultivated Plants and Naturalized Plants.**—Savages may live on the natural and spontaneous productions of nature, but civilized man provides for his food by the cultivation of certain plants and by the rearing of animals. There have been enumerated nearly a thousand species of plants which are eaten by man; comparatively few of these are cultivated, but some of them are raised to such an extent as to form a conspicuous feature of the vegetation of any civilized country. They may, therefore, properly be noticed here, although their distribution is due to artificial rather than to natural causes.

Savage and semi-barbarous people rely more upon fruits, roots, and leaves of plants; civilized people more upon a few cereal grains, sometimes called *bread-grains*. In England these are called simply *corn;* in America, *grain*.

The chief cereals of the world belong to nine genera, producing, respectively, wheat, rye, oats, barley, buckwheat, maize (or Indian corn), rice, millet, and sorghum. All these are annual plants, all except buckwheat belong to the grass family (Gramineæ), and all exist in numerous varieties; all except maize originated in the Old World, and all have been cultivated from remote antiquity.

(1, *a*) *Bald Wheat.* (1, *b*) *Bearded Wheat.* (2) *Rye.* (3) *Barley.* (4) *Oats.* (5) *Buckwheat.*

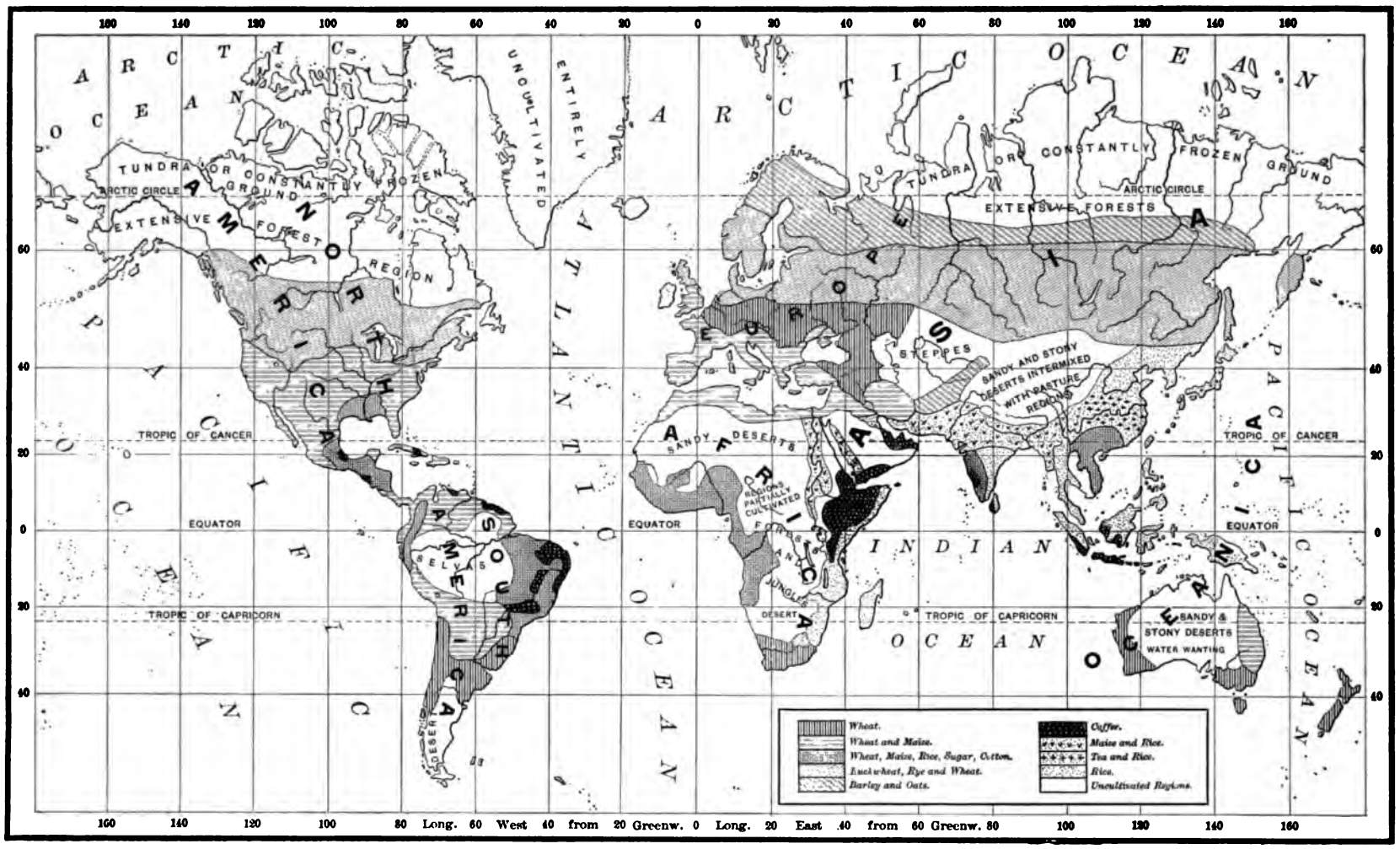
Cereals.

The cereals, as they are annual plants, compiete their existence during a single summer; therefore they are widely diffused over the earth, because in nearly every part of the world inhabitable by civilized man there is a summer long enough to ripen grain.

(6) *Maize.* (7) *Rice.* (8) *Millet.* (9) *Sorghum.*

Cereals.

73. Perhaps the most striking feature in modern civilization is the transportation of food, more particularly grain, for long distances. Until steam was used for transportation the food-crops had to be grown near the places where they were consumed. There was a comparatively small commerce in grain where it could be carried by water, but not much in other kinds of food. Now the cultivated crops of a country may be carried halfway around the world, and this change in transporting agricultural products has changed the aspect of various civilized countries and greatly modified the relative importance of the different cereals.



Distribution of Food-Plants.

Wheat is the best of bread-plants; it is now the most important one to the civilized world, and is more of an article of commerce between countries than are all the other cereals combined. It belongs more particularly to a temperate and warm temperate climate. (See map.)

Barley and oats grow farther north than wheat, but barley also grows in climates too hot for oats. It is an important crop in such sections as California, Egypt, and in other regions with similar climates. Both barley and oats formerly constituted a large part of the food of the human race, but in modern times wheat has to a great extent taken their place.

Rye will grow on poorer soils than wheat, and formerly it had an importance, both in Northern Europe and in America, that it has largely ceased to have since wheat came to be harvested by machinery and transported by steam. Rye-bread was once the chief bread of the people.

Buckwheat is used less than either of the other cereals in this list, and belongs chiefly to cool climates and to mountainous regions.

Maize (or Indian corn) is the only important cereal indigenous to America, and was cultivated by the natives, at the time of the discovery of America, from Peru to New England.

This cereal is very unlike all the others in appearance and in cultivation, and it is especially adapted to the conditions of barbarous as well as of civilized people. It is susceptible of hand cultivation on a small scale or of more extensive field cultivation. The plant is larger than any of the other cereals, of a more striking appearance, and it is the only one extensively eaten both green and ripe. The large ears, roasted or boiled green, are a nutritious food as well as a delicacy esteemed by savage and civilized man alike. Consequently, its cultivation has now spread even through all the barbarous and semi-civilized countries where the climate is adapted to its growth.

Rice is probably eaten by more people than any of the other cereals. It is the chief grain of China and Japan and of the more populous portions of India, but in each of these warm countries, as well as in Africa, some of the many kinds of sorghum and millet are also grown. These three grains are the special cereals of hot countries, although maize, wheat, and barley flourish in some of them. Most of the rice is cultivated in swamps or in irrigated ground, and by this means a greater number of people can be fed from a given area than from the cultivation of any other grain.

There are many other food-plants, some cultivated in one place and some in another in sufficient quantities to affect the aspect of the landscape. In the hot countries fruits, as a rule, constitute the largest proportion; in the temperate climates the cereals are predominant.

Among the tropical fruits the banana, date, cocoanut, and bread-fruit are the most celebrated.

In the temperate climates several species of grass, clover, roots, and other plants, are raised for the purpose of feeding domestic animals. These pasture- and forage-plants constitute in many regions the most distinctive feature of the cultivated vegetation.

In addition to these, there are various other plants cultivated for special products, either for food, for textiles, for dyestuffs, or for other articles of commerce.

Tea is the product of a small shrub cultivated in China, Japan, and India, the dried leaves of which constitute the tea of commerce.

Coffee is the seed within the berry produced by small trees grown in various tropical countries. The chief coffee-producing countries of the world are Brazil and the East Indies, but smaller quantities are grown in various other lands.

Sugar-cane, which before the discovery of America was grown on only a very small scale, has now extended to nearly all tropical countries. Sugar was a luxury until within the present century, but now that it is produced from beets grown in temperate climates, as well as from the cane of tropical plants, it has become a common and cheap article of food.

Formerly, flax and hemp were the chief textiles of the world, but during the last sixty years cotton has become the most important. Jute and a few other fibrous plants are used for making ropes and coarse fabrics.

74. **Naturalized Plants.**—Along with man and his cultivated plants many weeds have migrated. By his aid, although often without his consent, they have been carried to all parts of the world, and often have so spread as to check the native vegetation and change the aspect of the landscape. Nearly all the most troublesome weeds of America are natives of the Old World, and, in turn, plants from America have invaded Europe and Asia as weeds, and have even spread to the distant isles of the Pacific.

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Domestic animals in several ways change the character of the vegetation of a country. Grasses and other forage-plants cultivated for their food sometimes become the most conspicuous forms of vegetation, and sometimes they exterminate native plants. The animals themselves frequently obliterate indigenous varieties of vegetable life.

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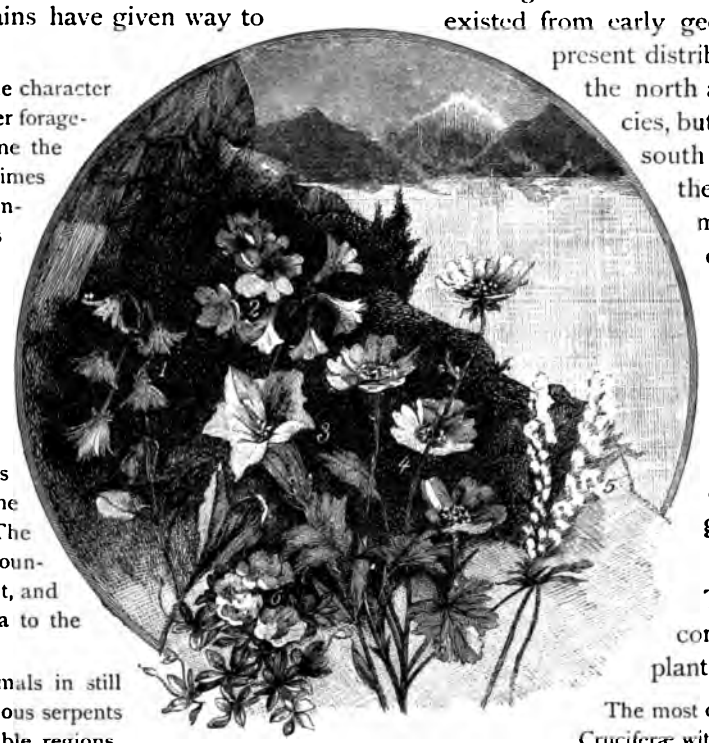
Man has modified the distribution of animals in still another way. Many noxious species and poisonous serpents are destroyed by him, and are, over considerable regions, exterminated. On the other hand, other species, harmless of themselves, although not especially useful, spread as he makes the country more suitable for their home and furnishes the means of their subsistence. Predatory quadrupeds, poisonous serpents, hawks, and other undesirable animals, diminish with civilization, while singing-birds and similar harmless creatures increase.



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Alpine Plants.

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Different regions have, therefore, very unlike faunas and floras, and naturalists have divided the earth's surface into what have been styled floral and faunal regions or realms, each characterized by certain kinds of animals or plants. Like all other artificial arrangements, this has been unsatisfactory. The regions are so poorly defined in nature that naturalists are not agreed amongst themselves as to what constitutes a region, whether the floral and faunal regions coincide, or, indeed, how many there are of each. The number as devised by various authors ranges all the way from five to twenty.

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This arrangement of the land-masses which appears to have existed from early geological ages is closely related to the present distribution of both animals and plants. At the north a great similarity exists among the species, but with each progressive stage toward the south the diversity of kinds increases. As the distribution of life is somewhat rudely marked by belts corresponding to the climatic zones, such belts have been indicated on the maps, pp. 106–107 and 112–113. The boundaries of the various plant-regions, as shown on th map, do not vary essentially from t' corresponding annual isothermal lin but in representing the distribution c animals certain characteristic faunal r gions have been recognized.

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The Arctic flora is essentially the same all around the world—in Northern Asia, Northern Europe, and in the islands north of them, in Greenland, and in Arctic America. Every species is not found spread throughout all these lands, but so many are, and the others are of such character, that the same flora may be said to extend around the earth.

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This is perhaps the most striking fact in connection with Botanical Geography—that the Arctic flora, although so insignificant in appearance and so limited in species, is more widely distributed over the globe than any other flora.

Some of the species found on the summits of the Andes, of the Rocky Mountains, of the Sierra Nevada, of the Alps, of the Caucasus, and of even the Himalayas, are the same as the species found in Lapland, in Spitzbergen, in Greenland, and in Arctic America.

80. **The North Temperate Zone.**—If the various forms of plant-life of the Western United States, of the Eastern United States, of Europe, and of Asia, in similar climates, are compared, they will be found to differ in species, but to have a great number of genera and families in common. Nearly all families of plants found in Europe and Asia are found in the United States also; most of the genera are likewise the same, but the species, as a whole, differ.

For example, there are many kinds of oak in California and Oregon, but they differ entirely from the oaks of the Eastern United States; not a single species is the same. Both these, in turn, differ from the oaks of Western Europe, and these, again, from those of Eastern Asia. The genus extends all around the earth, but is represented in different regions by totally different species—that is, in traveling eastward across the lands of the Temperate Zone from California to Japan one would find oaks nearly all the way, but would be continually coming to new kinds, while the varieties first seen would disappear.

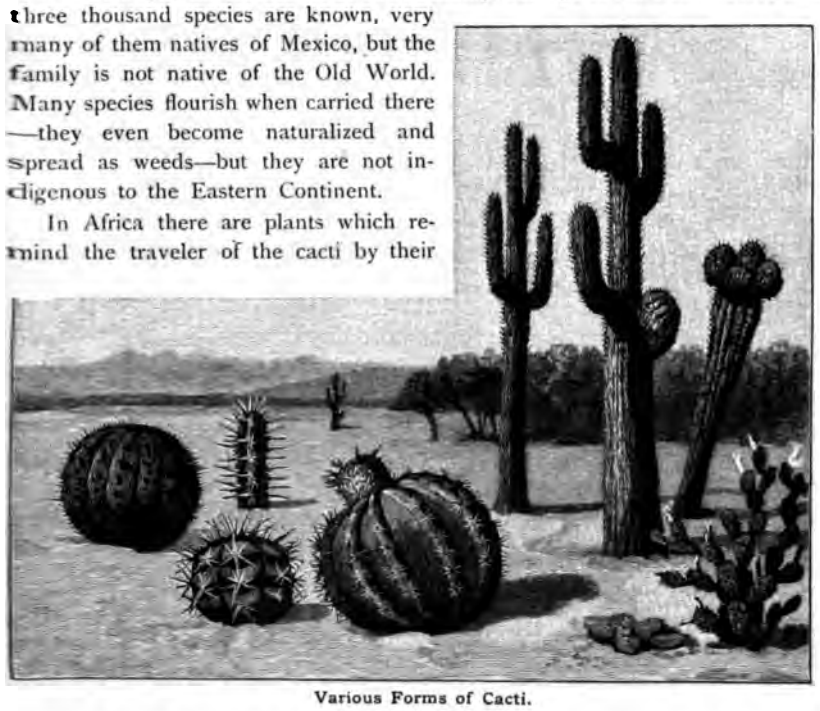
The same is true of a great many other genera. There are pines in each of these countries, but the species differ; there are maples, but the species are unlike; and a similar diversity exists even among the simpler herbs. Some few species are found widespread in both continents, but most of them are different. The traveler sees forms that seem somewhat familiar to him because he knows other species of the same genera.

The trees on the opposite sides of the two great continents differ in another way. The trees of the Eastern United States more closely resemble those of Japan and Eastern Asia than they do those of England and Western Europe. In a similar way the trees of California and Oregon more closely resemble those of Western Europe in many respects than they do those of the Eastern States, and they thrive better when planted on the western side of Europe than on the eastern side of their own continent. This is, perhaps, due to the differences in the climate of the two sides of the continents. (See p. 72.)

81. **The North Sub-Tropical Zone.**—Passing farther southward and comparing the flora of Mexico with that of Northern Africa, and this in turn with that of Asia, a still wider difference is observed. Certain families become prominent on one continent which are rare, or even entirely absent, on another.

For example, the Cactaceæ, or cactus family, belongs to America. More than three thousand species are known, very many of them natives of Mexico, but the family is not native of the Old World. Many species flourish when carried there—they even become naturalized and spread as weeds—but they are not indigenous to the Eastern Continent.

In Africa there are plants which remind the traveler of the cacti by their general shape, but they belong to other families—mostly to the euphorbias. The plants of the dry, hot regions in Asia differ from those of either Africa or America.



Various Forms of Cacti.

82. Passing still farther south to the **Equatorial Belt,** still wider differences are found; the forests of Brazil, those of Central Africa, and those of Southern India, are unlike in their character, entirely so in their species, and largely so even in their genera. All are tropical in their general appearance, and are yet very unlike in their special characteristics. In all of them, however, species are much more numerous than in the forests of temperate climates, several thousand species of trees belonging to this belt.

Perhaps the most characteristic and striking family of tropical forest vegetation is that of the palms, the crowning glory of endogenous vegetation.

83. **The South Temperate Zone.**—But it is between the southern extremities of the continents that the widest differences prevail. The floras of the southern part of South America, of Southern Africa, and of Australia are even more unlike than those of the respective regions of the equatorial belt. They are unlike in kind, in the number of their species, and very unlike in their aspect.

The flora of the southern part of South America is scanty in quantity and poor in the number of its species. That of the southern part of Africa is one of the richest on the globe in the number of its species; more than fourteen thousand have been described, or twice as many as grow in all that broad part of North America north of Mexico. The vegetation of Australia is reasonably rich in species, and very unlike that of any other part of the world in its botanical character and in its aspect.

84. **North America.**—The vegetation of North America as distinguished from that of Europe and Asia is characterized by the large number of its species of trees, by the size and grandeur of many of them, and by the number of genera of trees and shrubs which have survived from the Tertiary Age.

The forests extend beyond the Arctic Circle only in Alaska and in the northwestern part of British America. On the eastern side the forests reach northward only to the southern coast of Labrador.

As elsewhere in the Northern Hemisphere, the forests of the cooler regions are composed chiefly of evergreen trees, mostly species of pine, spruce, and fir. The forests attain their greatest development in the belt which stretches across Southern British America and the northern half of the United States.

As regards the number and grandeur of the species, half a dozen attain the height of over 200 feet, and the giant *Sequoias* of California, the greatest trees of the world, are often over 300 feet high and have a diameter of more than 30 feet. More than 400 different species of trees are described as native of the United States, and the number of these which are valuable for timber is too great to be enumerated in a text book. The great forests of deciduous trees found in portions of the Mississippi Basin are among the characteristic features of North American forests.

In the central part, treeless regions extend from the Gulf of Mexico far to the north. The western edge of this belt is comparatively dry, but the eastern portion embraces the most fertile and the most verdant prairies of the world.

The drier regions of the interior have a more shrubby vegetation, more particularly of low shrubby species known as sage-brush, chiefly species of *Artemisia;* but the shrubby vegetation is made up of numerous species sometimes scattered, and again dense enough to form chaparral, especially southward and westward.

The western slopes of the mountains near the Pacific coast from the Bay of San Francisco to Alaska are clothed with the grandest forests of temperate climates, some of them exceeding even the rankest tropical forests in the grandeur of their trees and in the actual amount of wood on the ground.

Mexico is characterized by striking and peculiar forms, the cactus and the maguey families being the most characteristic. Some of the cacti have stiff tree-like trunks 30, or even 50, feet high; others are fleshy and melon-shaped; still others are as slender as vines, and most of the species produce large and specially showy flowers. Equally characteristic are the *agaves*, to which the century-plant and the maguey belong. In Central America, which is the most tropical part of North America, there is a profusion of valuable woods, of which mahogany is the most noted.

As this continent stretches from the frozen north to the thermal equator, all the cultivated plants of the world may be found within its area.

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Some of the species found on the summits of the Andes, of the Rocky Mountains, of the Sierra Nevada, of the Alps, of the Caucasus, and of even the Himalayas, are the same as the species found in Lapland, in Spitzbergen, in Greenland, and in Arctic America.

80. **The North Temperate Zone.**—If the various forms of plant-life of the Western United States, of the Eastern United States, of Europe, and of Asia, in similar climates, are compared, they will be found to differ in species, but to have a great number of genera and families in common. Nearly all families of plants found in Europe and Asia are found in the United States also; most of the genera are likewise the same, but the species, as a whole, differ.

For example, there are many kinds of oak in California and Oregon, but they differ entirely from the oaks of the Eastern United States; not a single species is the same. Both these, in turn, differ from the oaks of Western Europe, and these, again, from those of Eastern Asia. The genus extends all around the earth, but is represented in different regions by totally different species—that is, in traveling eastward across the lands of the Temperate Zone from California to Japan one would find oaks nearly all the way, but would be continually coming to new kinds, while the varieties first seen would disappear.

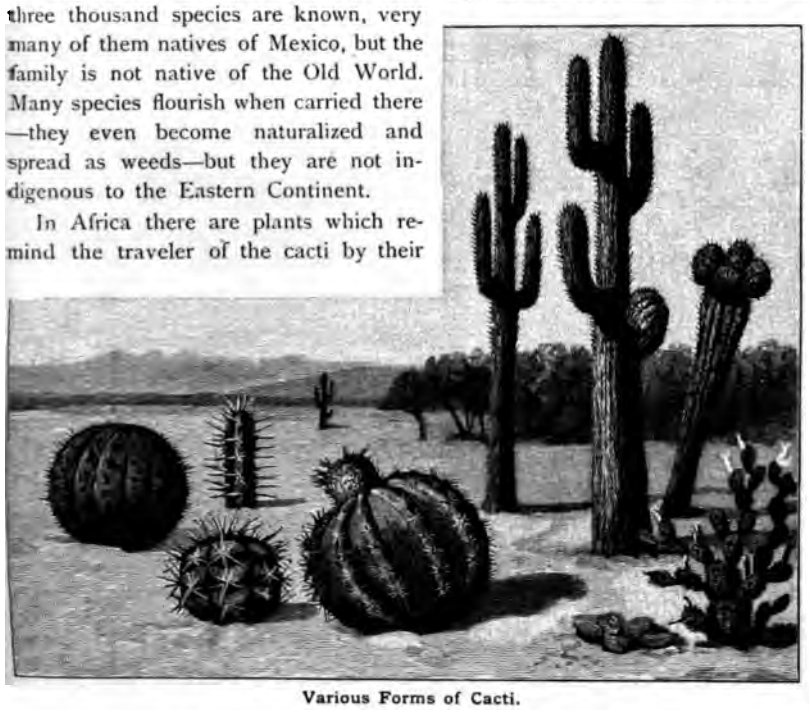
The same is true of a great many other genera. There are pines in each of these countries, but the species differ; there are maples, but the species are unlike; and a similar diversity exists even among the simpler herbs. Some few species are found widespread in both continents, but most of them are different. The traveler sees forms that seem somewhat familiar to him because he knows other species of the same genera.

The trees on the opposite sides of the two great continents differ in another way. The trees of the Eastern United States more closely resemble those of Japan and Eastern Asia than they do those of England and Western Europe. In a similar way the trees of California and Oregon more closely resemble those of Western Europe in many respects than they do those of the Eastern States, and they thrive better when planted on the western side of Europe than on the eastern side of their own continent. This is, perhaps, due to the differences in the climate of the two sides of the continents. (See p. 72.)

81. **The North Sub-Tropical Zone.**—Passing farther southward and comparing the flora of Mexico with that of Northern Africa, and this in turn with that of Asia, a still wider difference is observed. Certain families become prominent on one continent which are rare, or even entirely absent, on another.

For example, the Cactaceæ, or cactus family, belongs to America. More than three thousand species are known, very many of them natives of Mexico, but the family is not native of the Old World. Many species flourish when carried there—they even become naturalized and spread as weeds—but they are not indigenous to the Eastern Continent.

In Africa there are plants which remind the traveler of the cacti by their general shape, but they belong to other families—mostly to the euphorbias. The plants of the dry, hot regions in Asia differ from those of either Africa or America.



Various Forms of Cacti.

82. Passing still farther south to the **Equatorial Belt,** still wider differences are found; the forests of Brazil, those of Central Africa, and those of Southern India, are unlike in their character, entirely so in their species, and largely so even in their genera. All are tropical in their general appearance, and are yet very unlike in their special characteristics. In all of them, however, species are much more numerous than in the forests of temperate climates, several thousand species of trees belonging to this belt.

Perhaps the most characteristic and striking family of tropical forest vegetation is that of the palms, the crowning glory of endogenous vegetation.

83. **The South Temperate Zone.**—But it is between the southern extremities of the continents that the widest differences prevail. The floras of the southern part of South America, of Southern Africa, and of Australia are even more unlike than those of the respective regions of the equatorial belt. They are unlike in kind, in the number of their species, and very unlike in their aspect.

The flora of the southern part of South America is scanty in quantity and poor in the number of its species. That of the southern part of Africa is one of the richest on the globe in the number of its species; more than fourteen thousand have been described, or twice as many as grow in all that broad part of North America north of Mexico. The vegetation of Australia is reasonably rich in species, and very unlike that of any other part of the world in its botanical character and in its aspect.

84. **North America.**—The vegetation of North America as distinguished from that of Europe and Asia is characterized by the large number of its species of trees, by the size and grandeur of many of them, and by the number of genera of trees and shrubs which have survived from the Tertiary Age.

The forests extend beyond the Arctic Circle only in Alaska and in the northwestern part of British America. On the eastern side the forests reach northward only to the southern coast of Labrador.

As elsewhere in the Northern Hemisphere, the forests of the cooler regions are composed chiefly of evergreen trees, mostly species of pine, spruce, and fir. The forests attain their greatest development in the belt which stretches across Southern British America and the northern half of the United States.

As regards the number and grandeur of the species, half a dozen attain the height of over 200 feet, and the giant *Sequoias* of California, the greatest trees of the world, are often over 300 feet high and have a diameter of more than 30 feet. More than 400 different species of trees are described as native of the United States, and the number of these which are valuable for timber is too great to be enumerated in a text book. The great forests of deciduous trees found in portions of the Mississippi Basin are among the characteristic features of North American forests.

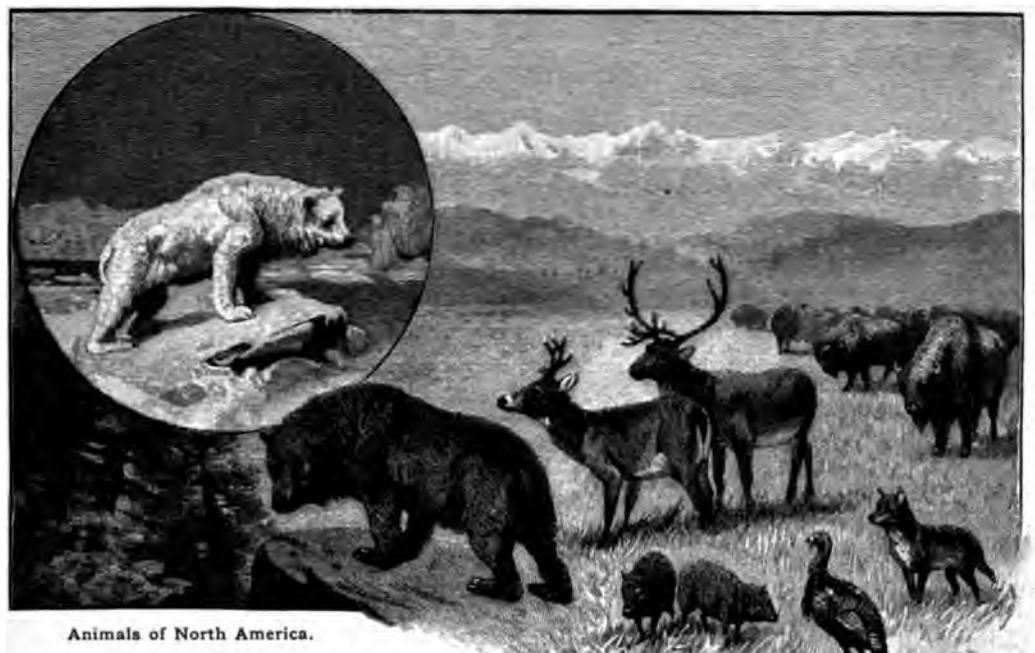
In the central part, treeless regions extend from the Gulf of Mexico far to the north. The western edge of this belt is comparatively dry, but the eastern portion embraces the most fertile and the most verdant prairies of the world.

The drier regions of the interior have a more shrubby vegetation, more particularly of low shrubby species known as sage-brush, chiefly species of *Artemisia;* but the shrubby vegetation is made up of numerous species sometimes scattered, and again dense enough to form chaparral, especially southward and westward.

The western slopes of the mountains near the Pacific coast from the Bay of San Francisco to Alaska are clothed with the grandest forests of temperate climates, some of them exceeding even the rankest tropical forests in the grandeur of their trees and in the actual amount of wood on the ground.

Mexico is characterized by striking and peculiar forms, the cactus and the maguey families being the most characteristic. Some of the cacti have stiff tree-like trunks 30, or even 50, feet high; others are fleshy and melon-shaped; still others are as slender as vines, and most of the species produce large and specially showy flowers. Equally characteristic are the *agaves*, to which the century-plant and the maguey belong. In Central America, which is the most tropical part of North America, there is a profusion of valuable woods, of which mahogany is the most noted.

As this continent stretches from the frozen north to the thermal equator, all the cultivated plants of the world may be found within its area.



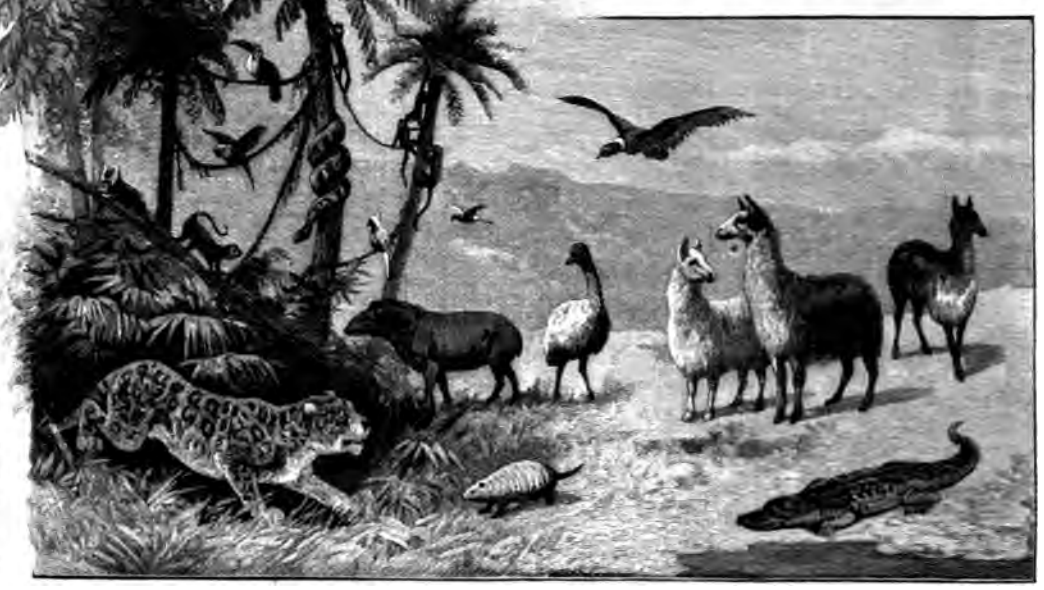
Animals of North America.

85. The animals of North America are, as a whole, less striking than those of the Eastern Continent. The buffalo or bison, which once roamed the central plains in such vast numbers, various species of deer, the caribou (or American reindeer), the musk-ox and polar bear of the north, the grisly bear of the west, the opossum, which is the only marsupial found far from Australia, the peccary of Texas and Mexico, the numerous long-tailed monkeys of Central America, are among the more characteristic and interesting species.

There are a great variety and a large number of species of reptiles, more particularly of serpents, but the proportion of venomous species among them is relatively small.

The birds and the insects, while like those of similar latitudes on the Eastern Continent, are, however, characteristic.

Maize, tobacco, squashes, Jerusalem artichokes, and probably also beans and potatoes, are among the cultivated plants originally introduced into Europe from North America and its adjacent islands. The turkey and some varieties of the dog are the only domestic animals now widely spread which have originated in North America.



Animals of South America.

86. **South America.**—The forests of South America occupy the Amazon basin, the eastern slopes of the Andes, and the mountains of Guiana and of Brazil. Some of these are among the rankest and most dense forests on the globe, and their tropical luxuriance has greatly impeded the progress of civilization on that continent.

The number of species is very great; among them are many of great use to mankind. Ornamental woods, such as Brazil-wood and rosewood, are found there; other trees produce gums, resins, perfumes, drugs, and medicines; of these, the cinchona tree of the Andes (or fever-bark tree), from which quinine and its preparations are made, is perhaps the most important to mankind.

Maize was cultivated by the natives at the time of the discovery of the country by Europeans, and potatoes are indigenous to the mountains of Chili.

The great plains which stretch across the center of the continent from Venezuela to Patagonia (see p. 35) vary in the aspects of vegetation in the different portions. The *llanos* in the basin of the Orinoco are grassy plains, covered during the rainy season with grasses and herbs interspersed with flowers of many kinds, some of which are of striking beauty, and with occasional clumps of trees. The *llanos* becomes dry and parched, however, during the dry season.

South of this the plains (*selvas*) in the equatorial belt are covered with forests. This part of the continent produces more India-rubber than any other part of the world.

Still farther south are the *pampas*, in the basin of the La Plata and southward. These plains are more level, perhaps, than any others of their size in the world, and are also grassy. In some places they are treeless for great distances; in other places there are a few scattered trees or shrubs. The most of this region, too, has its wet and dry season, and varies accordingly in appearance; a portion of it is so dry as to be almost a desert.

These plains furnish pasture for immense herds of cattle and flocks of sheep. The *pampas* extend southward into Patagonia, where the character of the vegetation changes with the climate. Grasses become coarser, and there is a larger proportion of shrubby vegetation.

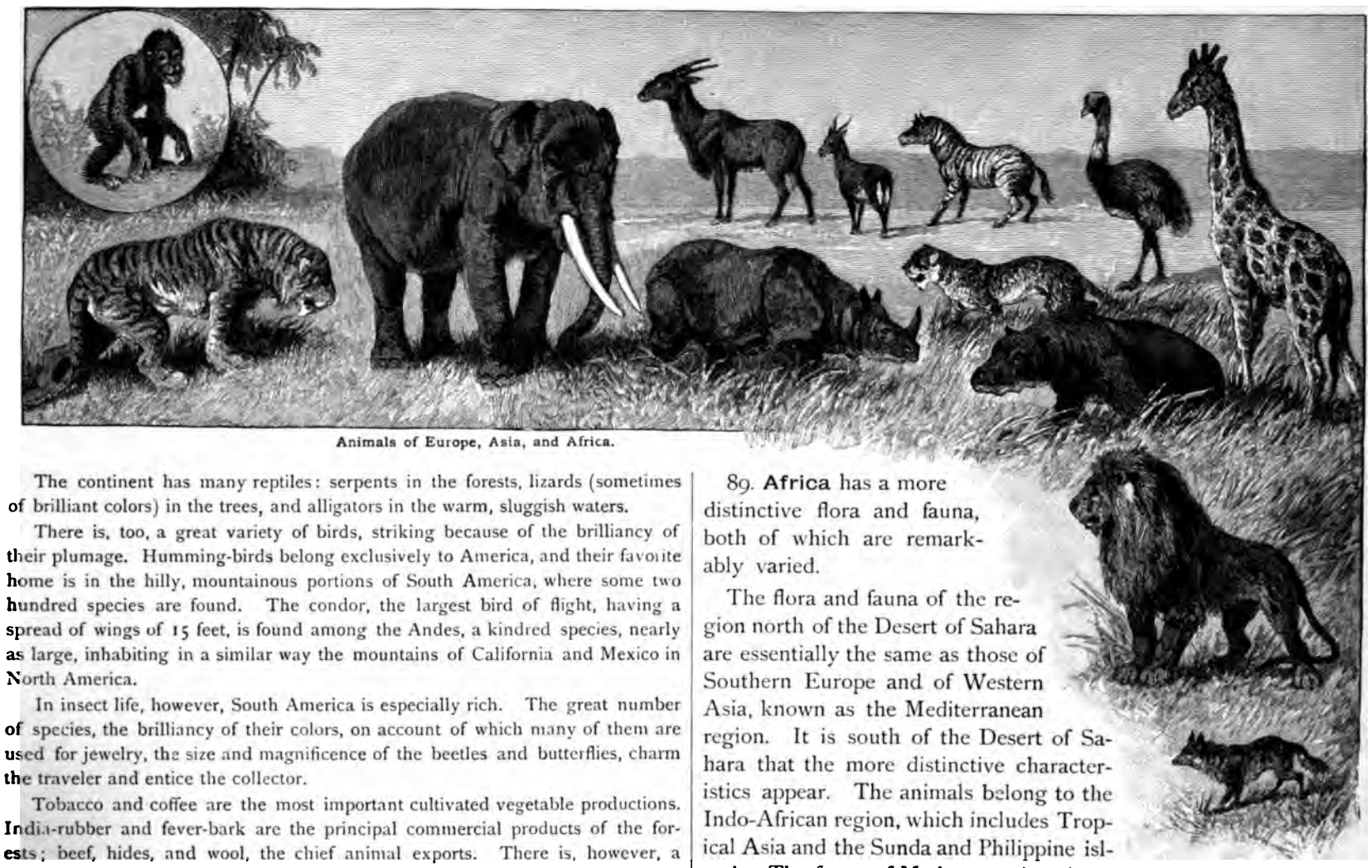
To the west of the Andes, within the belt of the tropical trade-winds (see p. 86), there is a stretch of desert between the Andes and the Pacific; some of this is absolutely barren, but much of it has occasional rains and supports a scanty vegetation.

The number of useful and ornamental plants found in South America is strikingly large. The largest of water-lilies (*Victoria Regia*), with flowers a foot in diameter and floating leaves sometimes a yard in diameter, are found in the warm waters of the quiet lagoons of the Amazon. The variety and richness of the flora of this continent have made it a favorite field for botanists.

87. Animal life in South America is, of course, intimately related to its vegetable life, and the species are chiefly such as live in forests. Among the more remarkable mammals are the sloth, the tapir, the jaguar, the armadillo, and the monkeys of many varieties and kinds.

The monkeys, which are very numerous, are of the tailed kind, and resemble the human form much less than do the monkeys of the Old World.

The llama, the alpaca, the vicuña of the Andes, and the guanaco of the plains are more or less domesticated by the native Indians, and were once the only beasts of burden (unless dogs be called such) used on the American Continent. They are somewhat taller than the sheep, but have some of the characteristics of the camel. Their wool is used for fabrics and their flesh for food.



Animals of Europe, Asia, and Africa.

The continent has many reptiles: serpents in the forests, lizards (sometimes of brilliant colors) in the trees, and alligators in the warm, sluggish waters.

There is, too, a great variety of birds, striking because of the brilliancy of their plumage. Humming-birds belong exclusively to America, and their favorite home is in the hilly, mountainous portions of South America, where some two hundred species are found. The condor, the largest bird of flight, having a spread of wings of 15 feet, is found among the Andes, a kindred species, nearly as large, inhabiting in a similar way the mountains of California and Mexico in North America.

In insect life, however, South America is especially rich. The great number of species, the brilliancy of their colors, on account of which many of them are used for jewelry, the size and magnificence of the beetles and butterflies, charm the traveler and entice the collector.

Tobacco and coffee are the most important cultivated vegetable productions. India-rubber and fever-bark are the principal commercial products of the forests; beef, hides, and wool, the chief animal exports. There is, however, a great variety of cultivated plants and of fruits, which are principally consumed at home, but some of which are exported.

88. **Europe** and **Asia** constitute but a single land-mass, with no important barrier between them. The flora and fauna of the temperate portions are consequently essentially the same. The general aspect of the vegetation and the characteristics of the animals are so very like those of North America that naturalists often class both in the same biological region or realm. There are fewer species of trees, but they belong mainly to the same genera as the trees of temperate North America.

In Southern or Tropical Asia, however, there is a change in the flora and fauna. The elephant and tiger are perhaps the best known of the larger animals. Here and on the adjacent islands is found the highest development of the ape or monkey tribe, the orang-outang presenting probably the nearest approach to the human form.

Nearly all the useful cultivated plants of the globe are indigenous to this land-mass; all the cereals named on page 104 except maize originated here. Among the important native plants are cotton, sugar-cane, tea, coffee, flax, hemp, and numerous fruits; on the adjacent islands, and to some extent on the mainland, the spices, cinnamon, allspice, cloves, nutmeg, and similar products.

In Europe the chief food-grains are rye, oats, and barley; maize is found to any considerable extent only in the southern portions—Spain, Portugal, and Italy.

In Asia, rice, sorghum, and millet are the chief bread-grains; in some of the countries maize is sparingly grown, but there are many vegetables and seeds belonging to the bean family which are practically unknown in our climate; many are without English names, and, although important to the inhabitants of those regions, they are not easily described in an elementary geography.

On this same land-mass originated all of the more important domestic animals, perhaps all except a few kinds of poultry.

89. **Africa** has a more distinctive flora and fauna, both of which are remarkably varied.

The flora and fauna of the region north of the Desert of Sahara are essentially the same as those of Southern Europe and of Western Asia, known as the Mediterranean region. It is south of the Desert of Sahara that the more distinctive characteristics appear. The animals belong to the Indo-African region, which includes Tropical Asia and the Sunda and Philippine islands. The fauna of Madagascar is unique.

The native vegetation of the continent is exceedingly varied in its character, but the relative proportion of plants that yield valuable products to the world is curiously small. In Southern Africa, while the vegetation is not extensive in quantity, it is marvelously rich in the number of its species. It is especially noted for the large number of species of the heath family and of those beautiful plants known in popular language as geraniums.

90. Among the animals are the elephant, the rhinoceros, the hippopotamus, the giraffe, several species of zebras, the eland and antelopes, and among the carnivorous animals the lion, the leopard, and the jackal. There are, also, numerous species of apes, monkeys, and baboons.

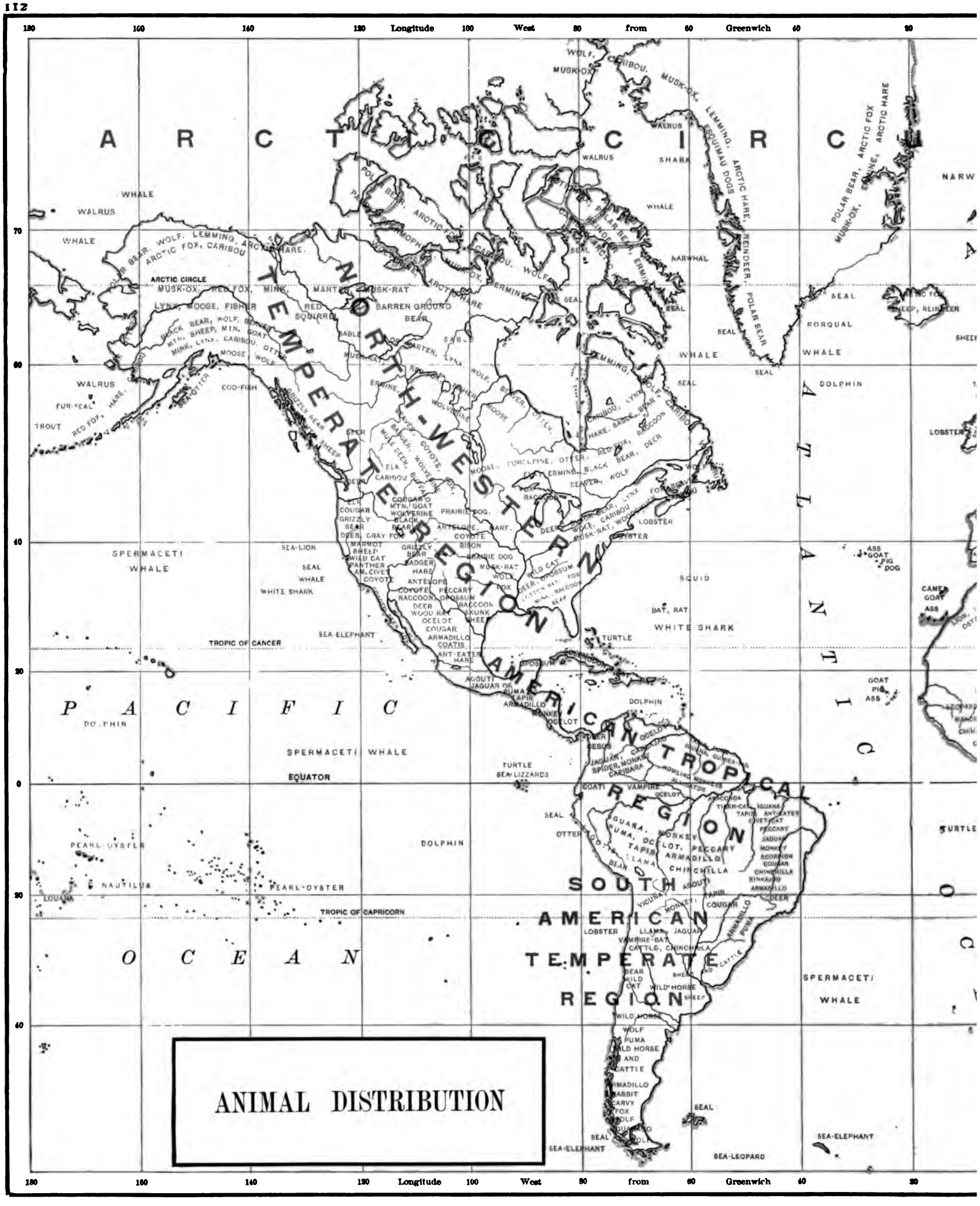
The chimpanzee and the gorilla resemble man in form nearly—if not quite—as closely as the orang of the East Indies.

Among the birds there are many beautiful kinds, but they are less striking than either those of South America, of the East Indies, or of Australia. The ostrich, the largest of living birds, is a native of Africa. This bird, after the introduction of firearms, seemed likely to be exterminated, as it was hunted for its feathers, but it has now been domesticated and is raised in large numbers. In Southern Africa, from this time on, it may be considered as a domesticated animal,—probably the only one which Africa has contributed to civilized man.

The crocodile is the most noted of its reptiles, but there are many serpents, some of which belong to the species of boa-constrictors, and are of enormous size.

The insects of Africa while very numerous are perhaps less striking than those of South America. Among them are many curiously "imitative forms;" that is, living insects closely resemble something else, some looking like a dried stick; still others resemble leaves or gravel-stones or other inanimate objects.

A kind of sorghum, called guinea corn, and millet are perhaps the most abundant of cultivated grains, but maize has become very widely spread over this continent.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ARCTIC CIRCLE
TROPIC OF CANCER
EQUATOR
TROPIC OF CAPRICORN
ARCTIC OCEAN
NORTH-WESTERN TEMPERATE REGION
AMERICAN TROPICAL REGION
SOUTH AMERICAN TEMPERATE REGION
PACIFIC OCEAN
ATLANTIC OCEAN
WALRUS
WHALE
SEAL
POLAR BEAR, ARCTIC FOX, CARIBOU
MUSK-OX, LEMMING, ESQUIMAU DOGS, ARCTIC HARE, REINDEER
POLAR BEAR, ARCTIC FOX, ERMINE, ARCTIC HARE, MUSK-OX
NARWHAL
RORQUAL
DOLPHIN
LOBSTER
COD-FISH
FUR-SEAL
TROUT
SPERMACETI WHALE
SEA-LION
WHITE SHARK
SEA ELEPHANT
SQUID
BAT, RAT
TURTLE
ASS
GOAT
PIG
DOG
CAMEL
SEA-LEOPARD
SEA-ELEPHANT
PEARL-OYSTER
NAUTILUS
TURTLE
SEA-LIZARDS
ANIMAL DISTRIBUTION


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POLAR REGION
NORTH-EASTERN TEMPERATE REGION
INDO-AFRICAN REGION
AUSTRALIAN REGION
LEMURIAN REGION
ATLANTIC OCEAN
PACIFIC OCEAN
INDIAN OCEAN
ARCTIC CIRCLE
TROPIC OF CANCER
EQUATOR
TROPIC OF CAPRICORN
Arctic Circumpolar Region.
North-western Temperate Region.
American Tropical Region.
South American Temperate Region.
North-eastern Temperate Region.
Indo-African Region.
Lemurian Region.
Australian Region.

91. **Australia** is the most isolated of the continents and has the most distinct and remarkable flora and fauna. Separated from all the other continents by deep seas, the emigration of land animals has been prevented since earlier geological ages.

The vegetation is unlike that found in other parts of the world. Many of the genera do not occur elsewhere. The foliage has a monotonous olive-green color, and the leaves are persistent. In the dry and hot regions are many species curiously adapted to the climate. The acacias turn the edges of their leaves to the sky, so that they cast but little shade and are less subject to evaporation. In other species the leaves are narrowed to a mere fringe.

Here are found many species of trees belonging to the genus *Eucalyptus*, known under the popular names of string-bark, blue-gum, etc. Some of these species grow to enormous height; the trees of one variety are sometimes over 400 feet high, and are the tallest trees of the world. Other species of the same genus have a wide reputation for counteracting malarial influences in the atmosphere, and have therefore been widely introduced into other countries.

92. Animal life varies so widely from that found in other parts of the world that a clear comprehension of it is almost impossible without a considerable knowledge of natural history.

Animals of Australia.

Most of the mammals represent forms which existed on the earth in an earlier age of its history, and belong to the natural order of marsupials. Among them are the kangaroos, of which there are thirty or forty species.

Still more remarkable are the duck-billed animal (Ornithorhynchus) and the Echidna: the former, a hairy quadruped smaller than the rabbit, has webbed feet and a broad bill like the duck; the latter, covered with quills like a porcupine, is a burrowing animal which feeds on insects and lies torpid in winter like a reptile. Both are reproduced from eggs, as are reptiles and birds.

None of the higher and more sensitively organized animals, such as are found on all the other continents, are indigenous to Australia. There are no native ruminants (animals that chew the cud like the cow or sheep), no flesh-eating animals of the cat kind (such as lions, tigers, panthers, leopards, etc.), and only a few beasts of prey. One is a kind of wild dog, called the dingo; another is known as the Tasmanian wolf, although not a wolf in the sense in which that word is used elsewhere.

The birds are as remarkable as are the mammals. Among them are the wingless apteryx, a bird of the size of a hen, with feathers looking like hair, the emu, sometimes called the Australian ostrich, the lyre-bird, and various kinds of the birds of paradise, with curiously brilliant plumage. There are also large numbers of parrots and cockatoos, which are unlike those of the other continents.

93. The **Flora and Fauna of Islands** differ materially with the position of the islands themselves. The plants and animals of continental islands are usually identical with those of the nearest continent. All the species of plants and animals found in the British Isles are also found on the neighboring continent of Europe. So, too, all the species found on Newfoundland, Long Island, and similar islands are identical with those found on the mainland. Moreover, the number of species, particularly of plants, found on the large continental islands like Great Britain, is often almost as great as that found on an equal area of the mainland.

On oceanic islands the distribution is very different. The number of species is usually much smaller, and the low or coral islands have a still more limited flora and fauna than the high islands like the Hawaiian or Feejee. The greatest scarcity is in the animal life; many islands are entirely without indigenous land mammals or land reptiles, and the birds often have strange and curious habits.

Not only is the number of species of plants usually small, but the number of flowering plants is relatively smaller than that of the flowerless plants. Where flowering species are widespread among oceanic islands, they are generally of kinds whose seeds can be transported by salt water, and have thus been borne to the islands by oceanic currents.

Many of the species, however, are local—that is, they are found on certain islands and nowhere else. For example, less than fifty species of flowering plants are indigenous to the island of St. Helena, but scarcely any of them are found elsewhere on the globe. They resemble the plants of Africa more nearly than they do the species of other lands, and belong mostly to African genera.

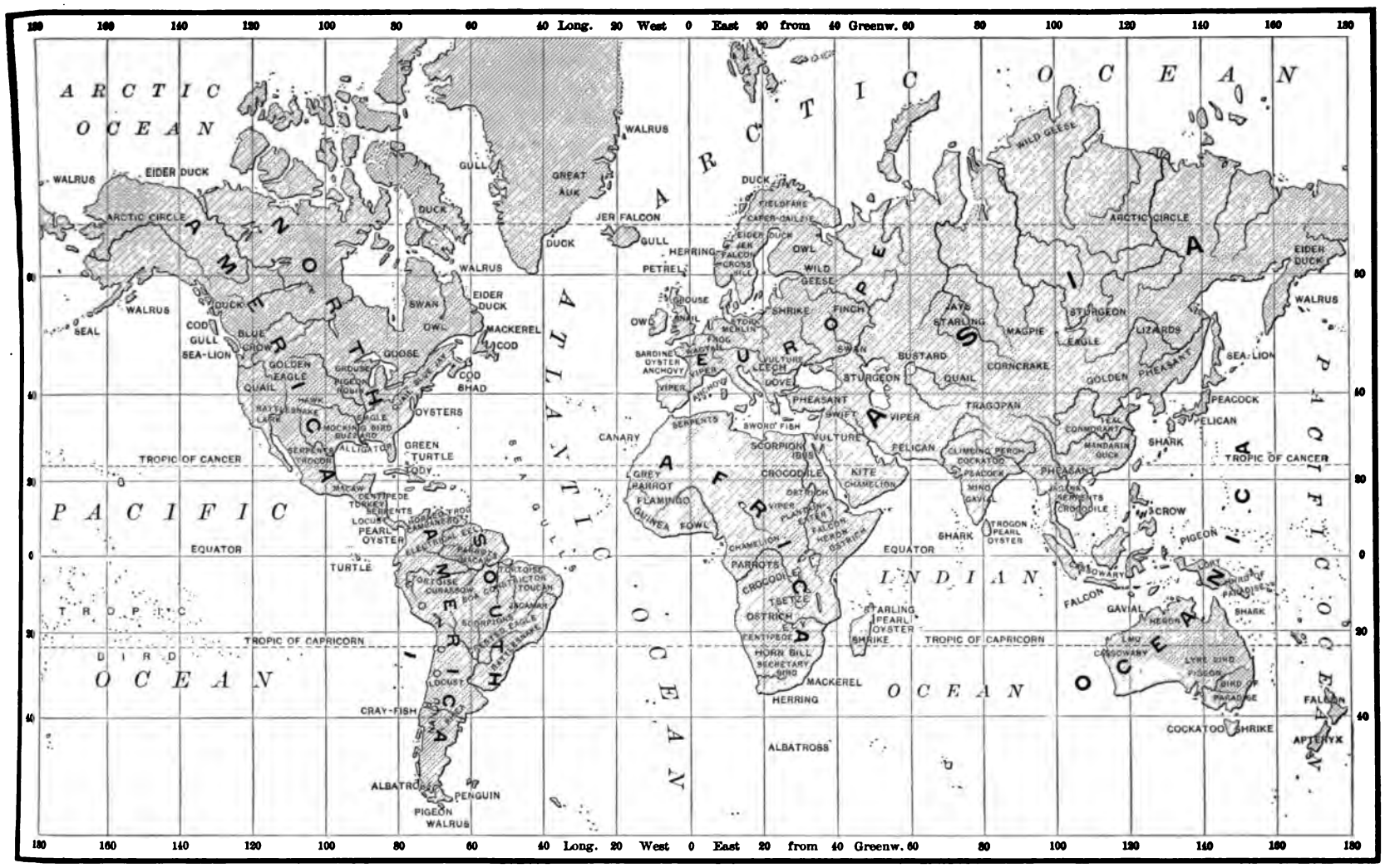
The Galapagos Islands are of volcanic origin, and lie on the equator 600 miles westward from the coast of South America. Most of the species of plants found on those islands are found nowhere else on the globe, but they resemble the plants of South America more closely than they do those of other lands. On these islands, too, are curious land reptiles, large lizards, remarkably like some of the creatures of earlier geological times, but unlike anything found elsewhere living on the earth. Similar facts might be enumerated of many other oceanic islands.

94. Much labor has been expended on the study of the geographical distribution of species on the various groups of islands, and, while certain philosophical principles underlie this distribution, it varies greatly in its details. For example, the flora of islands does not, necessarily, resemble that of the nearest lands. Sometimes the species of two islands near each other differ much more than do the species of other islands much farther apart; the depth of the seas between has an influence.

Thus, the flora of the West Indies is more closely related to that of South America than to that of North America, which continent the larger islands so nearly approach, but from which they are separated by the deep waters between Cuba and the mainland.

So, too, on the East Indian Islands the distribution of species appears to be in part related to the distance between the islands, in part to the depths and the currents of the intervening seas, and in part to prevailing winds.

The inference is that lands now separated by shallow seas may have been joined in recent geological times. It is very certain that the land of Great Britain was joined to that of France since the creation of the existing European species.



Distribution of Birds, Reptiles, and Fishes.

The distribution of the larger and more important animals, especially the quadrupeds, is shown on the map, pp. 112–113. In order to render the map more distinct and to make its inspection less confusing, some of the most interesting and noticeable birds, reptiles, and fishes, and the localities in which they are found, are here represented on a separate map.

95. The distribution of species, both of the animal and of the vegetable kingdom, is related to the changes of climate and to the changes in the geographical position of the land and of the sea which have occurred in recent geological times. This fact can, perhaps, be best illustrated by comparing the forests of North America with those of Europe and Asia.

The native forests of Europe are poor in species. There are not more than thirty-five species of trees indigenous to the whole area of Europe from the Mediterranean Sea to the Arctic Ocean and from the Bay of Biscay to the Urals, and a much smaller number essentially constitutes its forests. The forests of the United States are richer in kinds; there are nearly four hundred species of trees known, and in the Atlantic States alone more than a hundred species are common.

Nearly all the genera of European trees are represented in America. There are oaks, maples, pines, birches, and many other varieties in both continents, but these genera are represented in the United States by a larger number of species. In addition, there are many genera found in the United States which have no representatives in Europe; for example, the indigenous flora of Europe contains no hickory, magnolia, sassafras, or tulip tree, all of which are found in North America.

This gives the American forests an aspect and character different from other forests, and this peculiarity is true of South America as well as of North America. The American forests consist of more kinds and contain many more truly majestic species. Not more than one or two European species grow to the height of 100 feet, unless in very exceptional circumstances, while at least a dozen attain that height in the United States, and some species are frequently 200 feet high, and at least three varieties occasionally exceed the height of 300 feet.

Most of the genera of trees now growing in Europe and the United States were already on the earth in the Tertiary Age, and some in even earlier times. In certain geological formations leaves and other parts of plants are preserved with beautiful distinctness, and afford a considerable knowledge of the trees which grew in earlier geological ages. More than fifteen hundred species of fossil plants have been described.

During the Cretaceous and Tertiary ages extensive forests covered large portions of the Northern Hemisphere, even beyond the Arctic Circle. (See p. 16.) They comprised not only birches, poplars, elms, and other genera still native to Europe, but also other trees now found on that continent only among the fossils. Many of the genera still found living in America are extinct in the Old World, but their fossils show that they once flourished there extensively.

Hickory (*Carya*), tulip tree (*Liriodendron*), sweet-gum (*Liquidambar*), sassafras, cypress, *Libocedrus*, *Sequoia*, magnolia, and many other genera common in American forests are extinct in Europe, but their remains are found fossil in numerous places, some of them occurring even as far north as Nova Zembla and other islands of the Arctic Ocean.

Most of these genera have many fossil species, though only a few remain living in America. Thus, nearly twenty species of fossil *Sequoia* have been described scattered over the Northern Hemisphere, but only two species still

exist—the redwoods on the Pacific coast and the "Big trees" on the western slope of the Sierra Nevada, both in California. These survivors of an earlier flora are the feeble representatives of the majestic forests of a previous age.

Several fossil species of the tulip tree (*Liriodendron*) have been found, but only one species still exists, and that is one of the grandest trees of the American forests. Numerous other examples might be cited of genera abundantly represented in Tertiary forests, but of which there are now found only a few species in the flora of the Western Continent. Many types which have now disappeared from the Old World are still represented in the vegetation of America.

96. The explanation of these interesting facts is this: Extensive forests, in which these genera were represented in numerous and often noble species, flourished when there was a genial climate extending even beyond the Arctic Circle. Then came the ice age or the glacial period (see p. 89), during which the climate of the Northern Hemisphere grew gradually colder until ice covered the lands in a great cap as it still covers Greenland. It spread over the high mountains of the Eastern United States and extended south until it reached Pennsylvania and the Ohio River. Both Europe and America were subjected to this change of climate, and this period of intense cold, which lasted for thousands of years, gradually gained supremacy and slowly drove vegetation farther southward. In turn this period was succeeded by a warmer climate, under the influence of which the ice melted and the glaciers disappeared.

97. In the Old World the mountain-chains run easterly and westerly, and the Mediterranean Sea extends inland in the same direction more than 2000 miles along the entire southern border of Europe. The glacial period gradually drove the species southward, and many of them perished when they reached the impassable mountain-chains or the broad Mediterranean.

In America the mountain-chains run northerly and southerly, and the species retreated along the valleys southward from the United States into Mexico or even farther. When a milder climate gradually returned, they followed the slowly-melting glaciers, and thus many genera of trees that perished in the Old World were saved to America, though many species perished even here.

The wide distribution of the Arctic flora is also accounted for by the migrations incident to the glacial period. With the increasing cold, Arctic plants traveled southward to Mexico and to Africa, and when the ice again retreated northward to the Arctic regions, many species were left stranded, as it were, on the summits of high peaks, where they still linger in a climate suitable to their existence. Consequently, the same or very similar species, transported during the ice age, are now found on widely separated mountain-peaks.

Questions.—How is the distribution of species governed? What are annual plants? Biennial plants? Perennial herbs? What are the effects of heat and cold upon vegetation? Where do exogens attain their greatest development? Where are the largest endogens found? What is the effect of climate upon the variety of plant-forms? What peculiar climatic effects are noticeable in the equatorial belt? In the Temperate Zones? In the polar regions? How is the vegetation of these regions adapted to the climate? What are social species? Solitary species? Where is each most abundant? Name the chief cereals. Which one is most important? Which one is indigenous to America? Name some other cultivated food-plants. What effect has civilization produced upon the aspect of vegetation? Upon animal life? What are faunal and floral regions? How are Arctic and Alpine regions characterized? What are the peculiar features of the North Temperate Zone? Of the North Sub-Tropical Zone? Of the South Temperate Zone? Describe the vegetation of North America. The animals. What are some of the peculiarities of plant-life in South America? Mention some of the characteristic animals. Describe the flora and fauna of Europe and Asia. Of Africa. What are some of the remarkable peculiarities of Australian plants and animals? How do the flora and fauna of continental islands compare with those of the mainland? Is this true of oceanic islands? What notable differences occur in the variety of trees found in American and in European forests? To what cause is this ascribed? How is the wide distribution of Arctic flora explained?

IV. Mankind.

98. **Ethnology** is that branch of knowledge which has for its subject the natural history of man. Anthropology includes this and all else that relates to the scientific study of mankind. Anatomy treats of the parts and structure of the body. Physiology considers the functions and uses of the parts, and Psychology considers man's intellectual and spiritual nature.

99. Man has an animal nature. He bears certain resemblances to all the lower animals from the lowest to the highest. Like them all, he requires food and nourishment. He belongs to the vertebrate branch of the animal kingdom and to the mammals, and is subject to the same laws that govern other creatures of that class. In erectness of stature, in the vertical position of the skull above the spine, and in some other minor characteristics he differs from even the apes, which most nearly approach him in physical structure. But the greatest physical difference exists in the comparative size and structural complexity of the brain, which is the organ of the mental functions. Even recognizing these differences, it is almost impossible to comprehend that creatures so much alike in outward appearance and in bodily structure should be so widely separated in their endowments.

The wide gap which exists between man and the animals is produced by his intellectual and spiritual nature rather than by peculiarities of physical form, yet even in this respect he stands at the head and is the highest type of organic creatures.

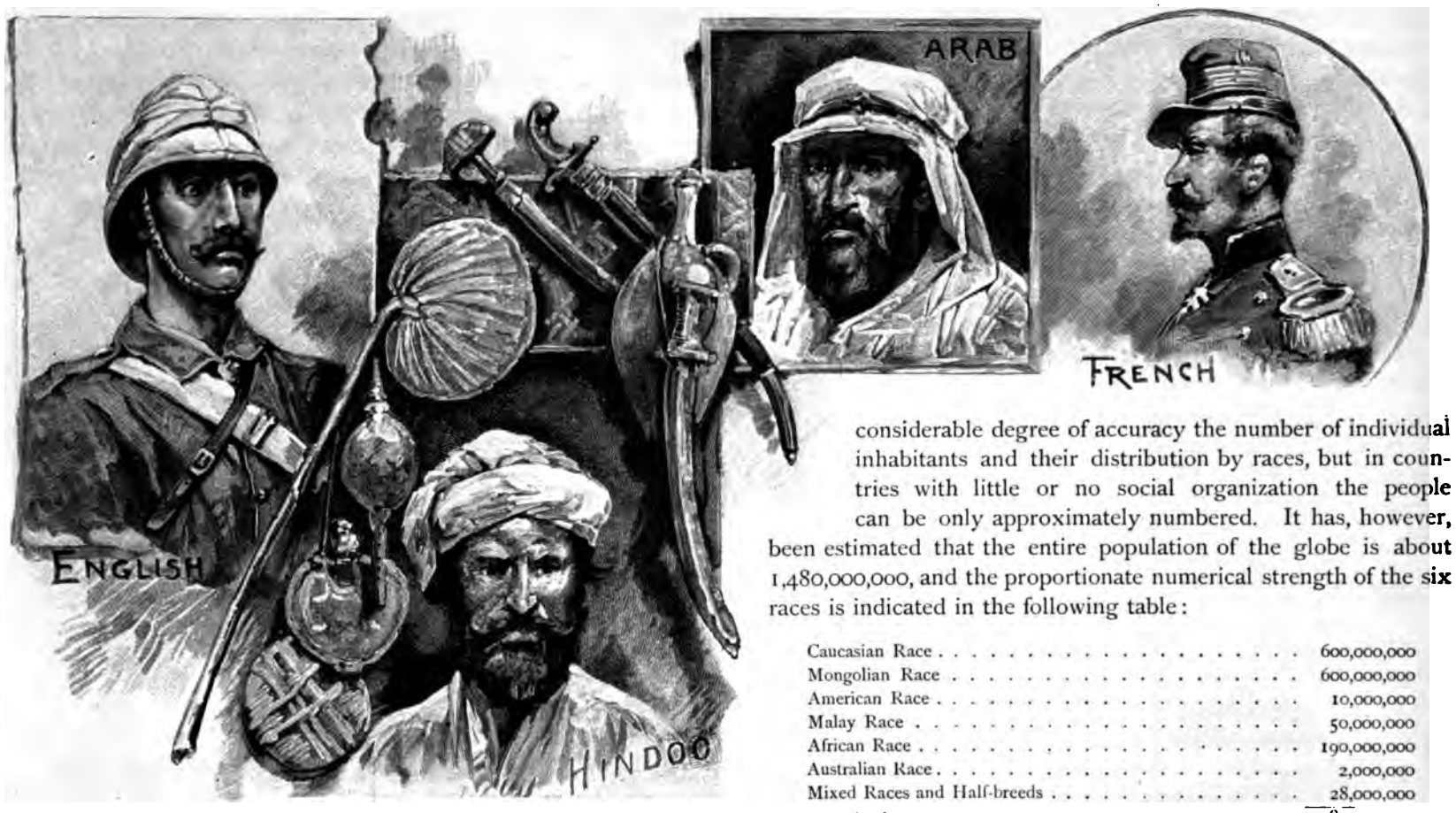
It is now very generally believed that the earth was inhabited by man for thousands of years previous to the dawn of history. Though in that long stretch of time pre-historic man made advancement similar to, but slower than, the strides which mark his progress since the beginning of civilization, yet, even in his primitive state, he was removed by his special endowments and his capabilities far above all other created beings. At that time the gulf which separated him from the lower animals was greater than the distinctions now existing between the civilized nations and savage tribes.

There are four theories as to the origin of mankind. Three are identical with the theories already stated regarding the origin of other species. (P. 96). The fourth is that the human body is the result of natural development from lower types of life, while man's spiritual nature is a special endowment by the Divine Creator.

100. **History** treats of the development of civilization, of the progress of mankind in culture, of the migration of peoples, of the origin, the growth, and the life of nations, and of all that relates to the progress of the race in intelligence and morality.

101. Mankind has everywhere a spoken language, by means of which ideas are communicated from one person to another. The acquisition of any language is a part of the education of the individual, and not a natural gift to the species, like the distinctive voices and cries with which animals are endowed. Every branch of the human family entertains some form of religious belief, and in various other characteristics, both physical and mental, it becomes apparent that mankind constitutes but a single organic species.

No other species, however, is so widely distributed over the earth. The intelligence of man enables him to clothe himself from the cold, to build houses to shelter himself from the extremes of climate, to construct boats with which to navigate the sea in search of food or other articles necessary for his convenience and comfort. His intellect enables him to subject the brute creation to his use, to cultivate, for food, plants which would not grow spontaneously, and in innumerable other ways to exercise over nature a control which the brutes do not possess. Therefore, he can live in climates as a man where he would perish as a brute, and his species is distributed from the equator to the polar regions.



102. **Races.**—Although mankind constitutes but a single species, yet striking differences in physical, mental, and moral characteristics produce varieties of this species which are known as *races*.

These races differ greatly in the color of the skin; they vary, also, in the color and the texture of the hair, in average stature, in the form of the skull and of certain other bones, and in other physical characteristics. A wide difference exists also in the capacity of the various races for intellectual and moral culture.

103. The classification of the varieties of man into races is founded on natural peculiarities, but is, nevertheless, artificial; consequently, different naturalists have devised very different systems. Some have founded the chief distinctions on color, others on the form or texture of the hair, and others on language or other characteristics.

The number of races proposed in these several systems varies from two to twenty, or more. One of the most convenient and popular divisions is that in which the white, the black, the red, the yellow, and the brown skins afford a basis for classifying mankind in five races; but the classification proposed by Buffon into six primary races is now very generally accepted, and is for many reasons the most convenient for use in the study of Physical Geography.

In accordance with the system of Buffon, the six primary races are (1) the *Caucasian*, (2) the *Mongolian*, (3) the *American*, (4) the *Malay*, (5) the *African*, and (6) the *Australian*.

Each of these is divided into a great number of sub-races, most of which are so connected by the intermediate shades of gradation, and are so blended with one another, that no sharp line of distinction can be drawn between them.

The various races originally inhabited separate geographical portions of the earth's surface, and no one race is adapted to every climate. The black race cannot flourish in cold regions, nor the Esquimaux in the tropics. The differences between the primary races have existed since the earliest dawn of history. The monuments and the manuscripts of Egypt show that the race distinctions that are found in that country to-day have been recognized there ever since a record of the people has existed.

In highly-civilized communities, where a careful census of the population is taken at stated periods, it is possible to learn with a considerable degree of accuracy the number of individual inhabitants and their distribution by races, but in countries with little or no social organization the people can be only approximately numbered. It has, however, been estimated that the entire population of the globe is about 1,480,000,000, and the proportionate numerical strength of the six races is indicated in the following table:

Caucasian Race	600,000,000
Mongolian Race	600,000,000
American Race	10,000,000
Malay Race	50,000,000
African Race	190,000,000
Australian Race	2,000,000
Mixed Races and Half-breeds	28,000,000
Total	1,480,000,000

104. **The Caucasian Race.**—The distinctive features of this race are a light-colored skin, straight or wavy hair, an oval face, the eyes at right angles with the nose, the teeth vertical, and the figure well formed and graceful.

No other race, however, presents such a diversity of typical characteristics, or such a strong contrast between its different representatives; even in the color of the skin there is a wide range from the dusky Hindoo to the blond Saxon. The straight-haired Arab and the curly-haired Irishman are quite unlike, and within this same race are classed the barbarous Bedouin and the cultured European.

It originally inhabited Southwestern Asia, North Africa, and nearly the whole of Europe, and during the last four centuries has spread to North America and South America, Australia, South Africa, and to many islands of the sea. It is the most cosmopolitan of the races, and lives under the greatest variety of conditions. The Scandinavians and Icelanders inhabit the coldest of civilized countries, while other branches dwell in tropical India. The white European races, however, do not well withstand a tropical climate; individuals can endure the heat, but the lighter races from Northern Europe have not spread and multiplied extensively in any hot country. The Italians, Spanish, and Portuguese have, however, established themselves in various tropical countries, as in equatorial America and some of the East Indian islands.

The Caucasian race has played the most important part in history, and to it the leading nations of the world belong. Its people are active and progressive: they have always absorbed and appropriated the better part of the civilization of other races, and they have aggressively carried their own to those that were more passive than themselves.

The civilization of this race originated in Western Asia and Northeastern Africa. The culture beginning there extended around the eastern end of the Mediterranean, including Palestine and Phœnicia, and, eventually, Cyprus, Greece, and Rome. With the march of time it overspread Europe, and finally was carried across the sea to other continents and islands.

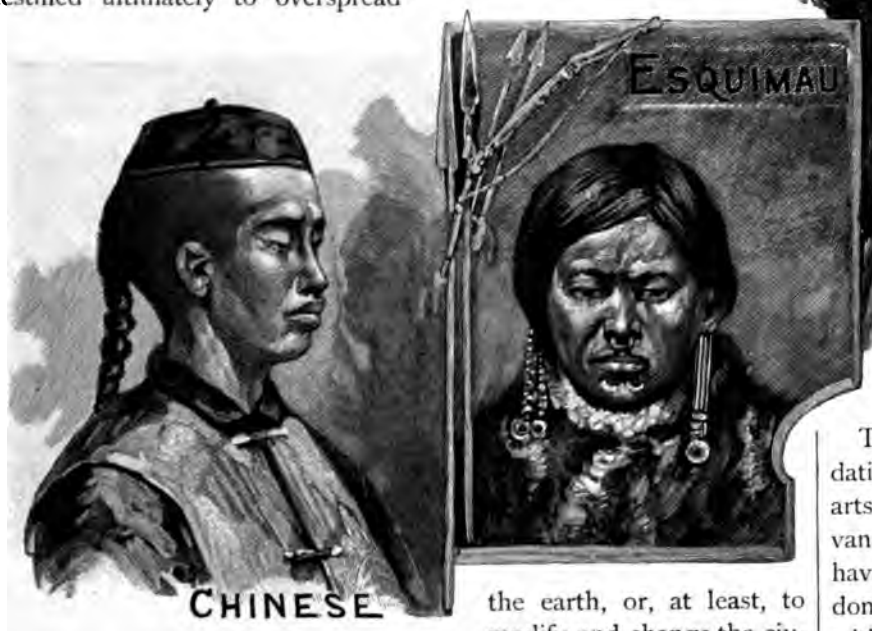
The most common division of this race is into three great branches, containing respectively the descendants of the three sons of Noah.

To the first class belong the people of North Africa and Arabia, the *Cushites*, or the accredited descendants of Ham.

The *Semites* (or *Shemites*), the descendants of Shem, constitute the second branch. They occupied the countries of Western Asia, the valley of the Euphrates and the Tigris, and Syria. To this branch of the race belong the "chosen people," the Israelites, and those tribes which, in the Middle Ages, were called Arabs.

The third branch is the *Aryan*, comprising the alleged descendants of Japheth, and including the Persians, the Hindoos, and the principal European nations, whose people are sometimes styled Indo-Europeans.

105. From time to time, the Caucasian race has migrated to countries belonging to darker-skinned and more passive peoples. These it has driven away and forced to seek new homes, or has conquered, and, while intermixing with them, has occupied the position of ruler. The Caucasian civilization is the only one that has aggressively pushed its way among other races, and it is the one that seems destined ultimately to overspread



the earth, or, at least, to modify and change the civilization of other peoples to a greater extent than it is itself to be modified by theirs.

106. There have been, in the historical period, a great many nations belonging to this race. Many of these nations have occupied separate regions, and within such areas numerous sub-races have developed. As a consequence, there are various types of the Northern European races—the Germans, the French, the Scandinavians, the English, and the Irish—differing sufficiently from one another to render their distinctive peculiarities readily recognizable.

107. The **Mongolian Race** has a yellow or olive-colored skin and straight, coarse black hair. The nose is small; the small black eyes are somewhat obliquely set; the forehead is narrow, and the cheek-bones project. Its individuals are, as a whole, rather smaller in stature than the average Caucasian. It occupies Eastern Asia, and one of its branches extends throughout those countries which completely encircle the Arctic Ocean. The representatives of this race are very numerous, outnumbering those of any other except the Caucasian.

It is subdivided into three main groups. The first or typical group comprises the Chinese, the Japanese, the Coreans, and the nations of Farther India.

The second group, called the *Turanian*, comprises various tribes of Central Asia, some of the Turks, the Magyars in Hungary, and the Lapps and Finns. These peoples in many of their characteristics seem intermediate between the Caucasian and the Mongolian race.

The third, or Arctic group, comprises certain tribes of Northern Asia bordering on the Arctic Ocean and in Kamchatka, and the Esquimaux of Arctic America

and Greenland. There is evidence that much of Europe was inhabited by this race during, or soon after, the glacial period.

The Chinese and Japanese have a highly-developed civilization dating back to remote times, and have made great progress in the arts. During the last few centuries, however, they have not advanced as have the European peoples, but of late years the Japanese have peaceably undergone a profound revolution. They have abandoned that exclusiveness which forbade intercourse and commerce with foreigners, have thrown open their ports to the ships of all nations, have assumed diplomatic relations with the civilized powers of the world, and have shown a remarkable aptitude in adopting modern ideas of education and government. The Coreans, until within a very few years, maintained an even more pronounced exclusiveness than the Chinese and Japanese, but have now made treaties with many of the civilized nations.

The Mongolians as a race are disciples of Buddhism, a religion which numbers among its votaries more than one-third of the human race. The Buddhala, or temple of Buddha, at Lassa, is visited annually by thousands of pilgrims. In Japan, Buddhism has ceased to be the national religion; it is on the decline in India, where it had its origin, and in many parts of China it is losing its popularity.

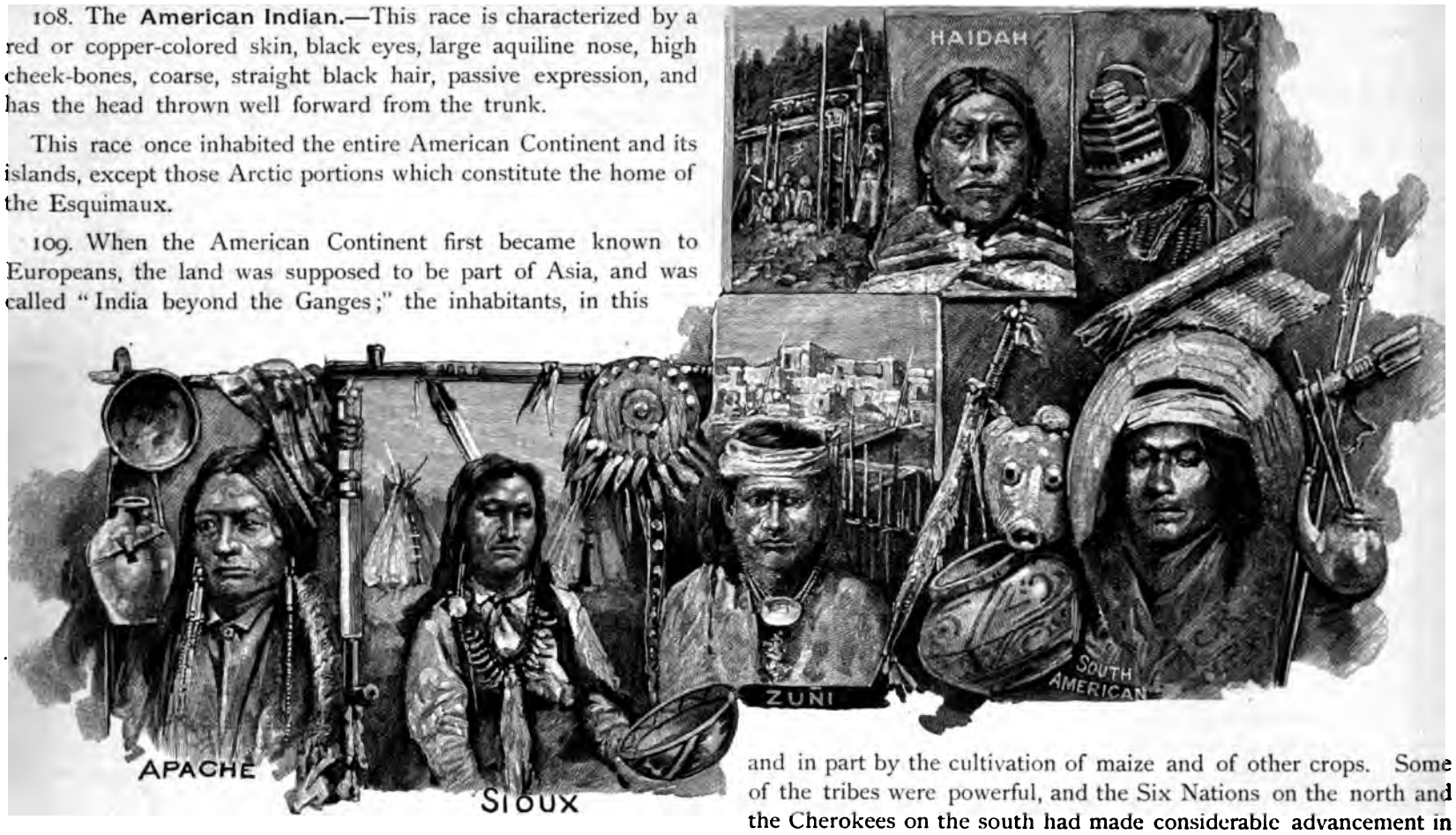
Some of the Tartar tribes and others of Central Asia are the largest and best-formed members of this race, while the Esquimaux of America, the Finns and Laplanders of Europe, and certain of the tribes of Arctic Siberia are of diminutive size, ungraceful form, and unattractive features.

While many of this race are barbarians, none of them are so low in savage life as either of the four succeeding races.

108. The **American Indian.**—This race is characterized by a red or copper-colored skin, black eyes, large aquiline nose, high cheek-bones, coarse, straight black hair, passive expression, and has the head thrown well forward from the trunk.

This race once inhabited the entire American Continent and its islands, except those Arctic portions which constitute the home of the Esquimaux.

109. When the American Continent first became known to Europeans, the land was supposed to be part of Asia, and was called "India beyond the Ganges;" the inhabitants, in this way, received the name of Indians. The epithet "red-skins," frequently applied to the aboriginal Americans, was in part the result of early impressions produced upon the minds of the explorers by the red paint with which the native adorned his face and body.



The red color of the skin is often so light, and so nearly approaches the yellow complexion of the Mongolian type, that the American Indian has by many writers been classed with that race. Some of the northern tribes, such as the Athabascans, possess traditions concerning their emigration across the Pacific, and a certain similarity also exists between the implements and the modes of life which characterized the American natives and those which belonged to the early stages of Asiatic or European civilization. Some writers also affect to discover a similarity between the languages of the Mongolians and the Indian dialects.

There has been much speculation as to the origin of the American Indians, and many theories have been advanced as solutions of the problem; but the same mystery extends to the origin of the other races and to the peopling of many other lands.

110. As a race it is more uniform in its physical features than either the Caucasian or the Mongolian; it is also more uniform in its intellectual development. At the time of the discovery of America and its settlement by colonies of Caucasians, some of the Indians of Mexico, Central America, and Peru had attained to many of the arts and institutions of civilization, but the great majority existed as savage tribes. There were hundreds of these tribes—some large, some small, differing greatly in their culture and in their language.

The lowest types were the "Diggers," of the Western United States, and the Patagonians. The Indians of the Plains were confederated in larger tribes, were of better physique, and lived entirely by the chase. The Indians of the Eastern United States were of even a higher grade of development, and lived in part by the chase and in part by the cultivation of maize and of other crops. Some of the tribes were powerful, and the Six Nations on the north and the Cherokees on the south had made considerable advancement in government and in the ruder arts.

The Indians of Alaska dwell mostly along the coast and on the various islands. They have many traits in common with their brethren of the Great Plains, but their diet consists principally of fish procured by an almost constant existence in canoes, and thus they acquire a stooping posture. On the other hand, the Apaches and the Sioux, who spend their lives in hunting, have an erect and symmetrical physique. The Haidahs are the most attractive and intelligent of the native Alaskans.

In Mexico lived the Aztecs, who displayed the highest type of advancement found among the aborigines of the New World. The descendants of the native tribes of this section, mixed in varying proportions with Spanish blood, constitute the Mexicans of to-day. In Central America there were also numerous tribes, some of which had reached a fair degree of civilization, but others were among the most savage of the Indians. In South America the Peruvians were the most noted of the many native tribes.

On the northern coast of South America, and more particularly on the Antilles, were the Caribs, more noted for their ferocity than any other tribe of the American Indians.

111. Most of the tribes, when brought in contact with civilization from Northern Europe, have greatly decreased in numbers, and but a few hundred thousands of the red race are now left in the United States and Canada. Some tribes have entirely ceased to exist; others have greatly diminished, and a few have adopted, or are now adopting, the arts of civilization. It is not probable that the Indians will become extinct, as many writers have predicted, but rather that a certain portion will acquire the prevailing habits and customs and ultimately be absorbed in the civilization of the country. In Mexico, Central America, and South America it is probable that they will always constitute a more considerable element in the population.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ARCTIC OCEAN
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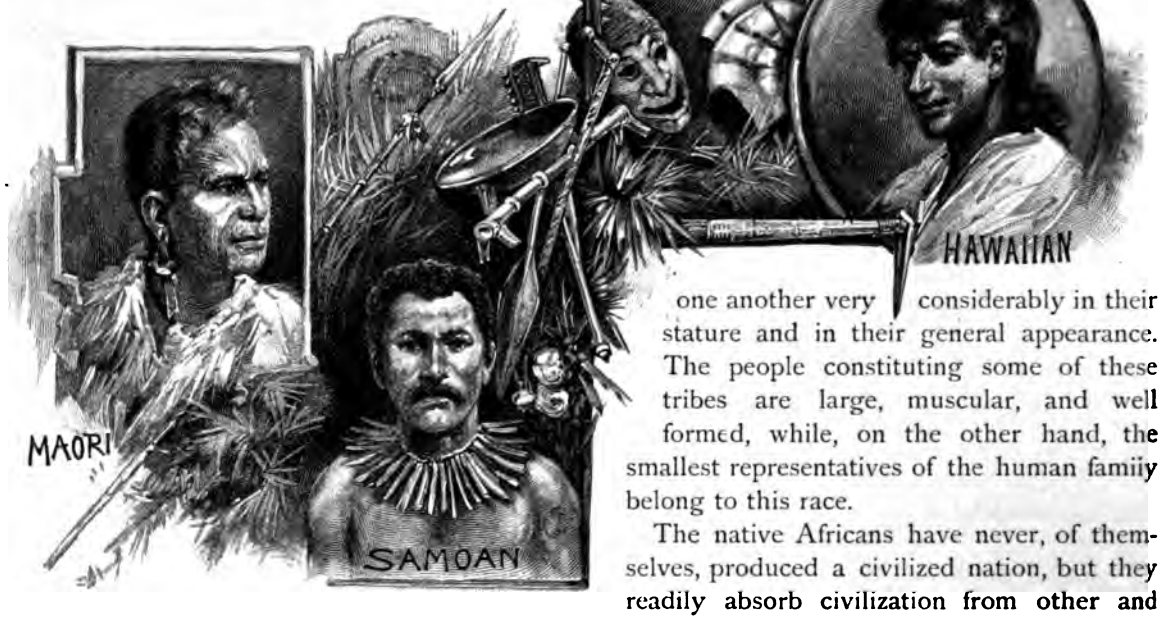
ICELAND
ARCTIC CIRCLE
ALASKA
ALEUTIANS
NAMOLOS
BRITISH AMERICANS
NORTH AMERICA
UNITED STATES
CANADIANS
ESQUIMAUX
INDIANS
HAYTIANS
HAYTI
CENTRAL AMERICA
TROPIC OF CANCER
HAWAIIAN IS.
EQUATOR
TROPIC OF CAPRICORN
TAHITI
POLYNESIANS
PACIFIC OCEAN
ATLANTIC OCEAN
SOUTH AMERICA
VENEZUELA
GUIANA
ECUADOR
PERU
BRAZIL
PARAGUAY
URUGUAY
PATAGONIANS
DISTRIBUTION
OF THE
HUMAN RACES


from Greenwich
20
40
60
80
100
120
140
160
180
ARCTIC OCEAN
SPITZBERGEN
NOVA ZEMBLA
FINLAND FINNS
OSTIAKS
RUSSIAN EMPIRE
KIRGHEEZ
KALMUKS
CHINESE EMPIRE
MANCHUS
THIBETANS
AINOS
KORIAKS
CHUKCHEES
NAMOLLOS
KAMCHADALES
COREA
JAPAN
ARCTIC CIRCLE
AUSTRIA
HUNGARY
CAUCASIANS
TURCOMANS
TURKS
PERSIA
AFGHANISTAN
BELUCHISTAN
ARABIA
INDIA
DRAVIDIANS
TRIPOLI
NEGROES
ABYSSINIA
SOMAULI
CONGO
CAPE COLONY
MADAGASCAR
TROPIC OF CANCER
EQUATOR
TROPIC OF CAPRICORN
INDIAN OCEAN
LUZON
MINDANAO
BORNEO
SUMATRA
MICRONESIANS
FEEJEE IS.
AUSTRALIA
EUROPEANS
NEW ZEALAND
PACIFIC OCEAN
Caucasian or White Race.
American Race.
Mongolian or Yellow Race.
Malay Race.
African or Black Race.
Australian Race.
The Most Important Secondary Races are Indicated in Red.

112. The **Malay Race** varies in color from very light brown to almost black. Its members are characterized by a flat face, with projecting cheek-bones, and black hair, which in some tribes is very curly and in others straight.

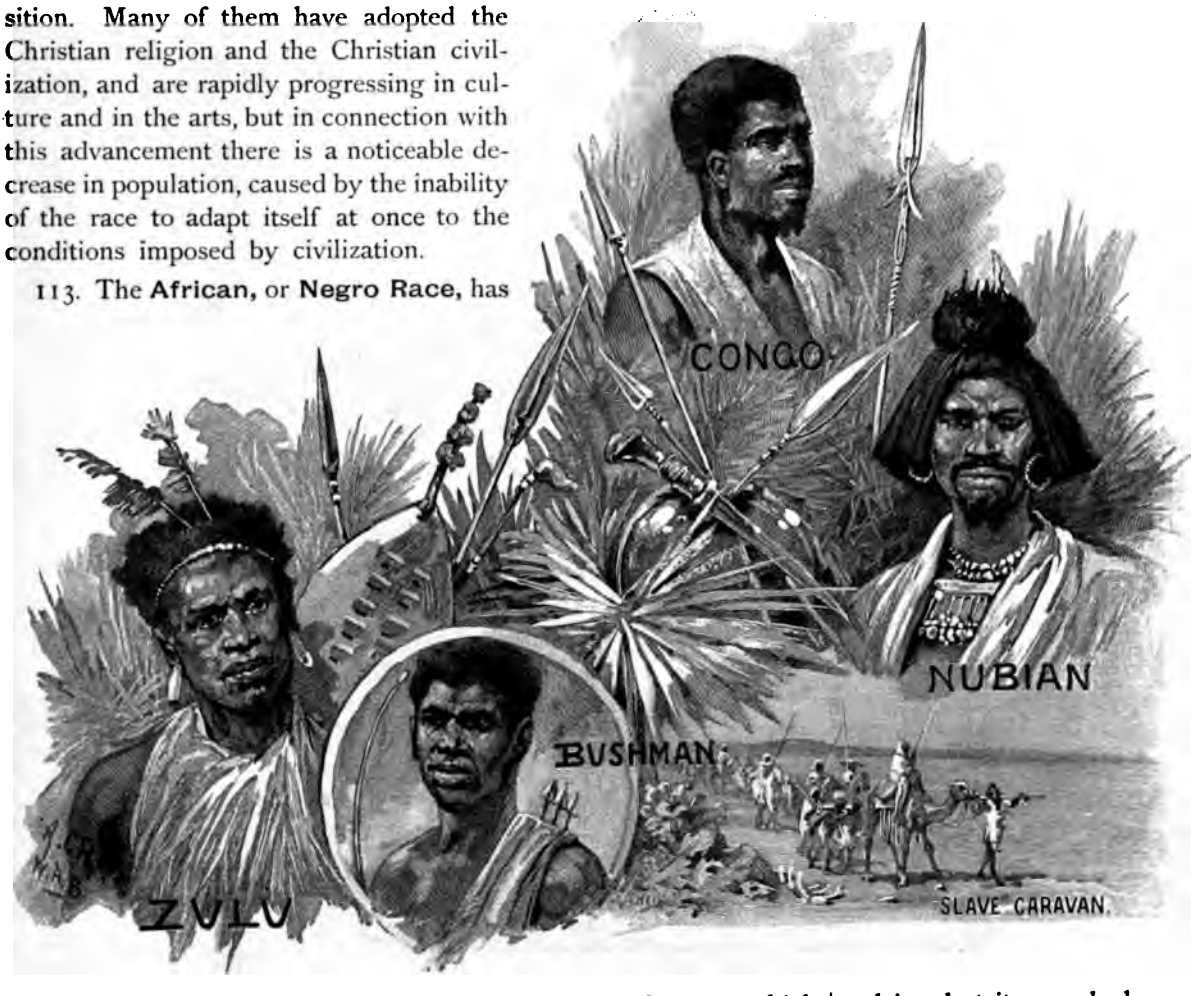
The peculiar features of this race are even less distinctly defined than those of either of the groups of mankind previously described. The Malay race proper inhabits the Malay peninsula and the neighboring islands. It is believed to have spread from this region and to have modified certain tribes in Southeastern Africa, besides forming the basis of many of those in the islands of the Polynesian group.

Some of the communities of this race are considerably advanced in civilization, while others present some of the lowest phases of savage life.



The natives of Hawaii, Tahiti, Marquesas, New Zealand, and some other islands of the Pacific are usually classed as belonging to this race, and are among the most beautifully formed representatives of the human family. The Maoris of New Zealand are larger, more powerful, and more savage than the people of the Polynesian islands to the eastward and northward, where the natives are usually somewhat smaller, although graceful in form and, as a whole, of mild and gentle disposition. Many of them have adopted the Christian religion and the Christian civilization, and are rapidly progressing in culture and in the arts, but in connection with this advancement there is a noticeable decrease in population, caused by the inability of the race to adapt itself at once to the conditions imposed by civilization.

113. The **African,** or **Negro Race,** has *a black skin,* black woolly or frizzly hair, a broad flat nose, thick *lips, and projecting jaws. The body is* active and muscular and the arms relatively longer than those of the other races. The negroes inhabit Africa south of the Sahara, and throughout this great region there are numerous tribes which differ from one another very considerably in their stature and in their general appearance. The people constituting some of these tribes are large, muscular, and well formed, while, on the other hand, the smallest representatives of the human family belong to this race.



The native Africans have never, of themselves, produced a civilized nation, but they readily absorb civilization from other and more enlightened peoples. In the northern and northwestern part of the Ethiopian region, where this race is more or less mixed with Arabian blood, a higher degree of culture has been reached than elsewhere, and in this section are found the bravest and also the most cruel warriors.

In the southern and southeastern portions there is probably some admixture of Malay blood. In this part of the continent are the Bushmen and other tribes, composed of individuals of diminutive size who are exceedingly low in culture. They were once quite numerous, but are now nearly extinct.

Most of the sea-coast of tropical Africa has a climate which is peculiarly unhealthful for the other races, some portions being so insalubrious to the lighter-colored Europeans that they can sustain life only by the use of drugs which counteract the miasmatic fevers.

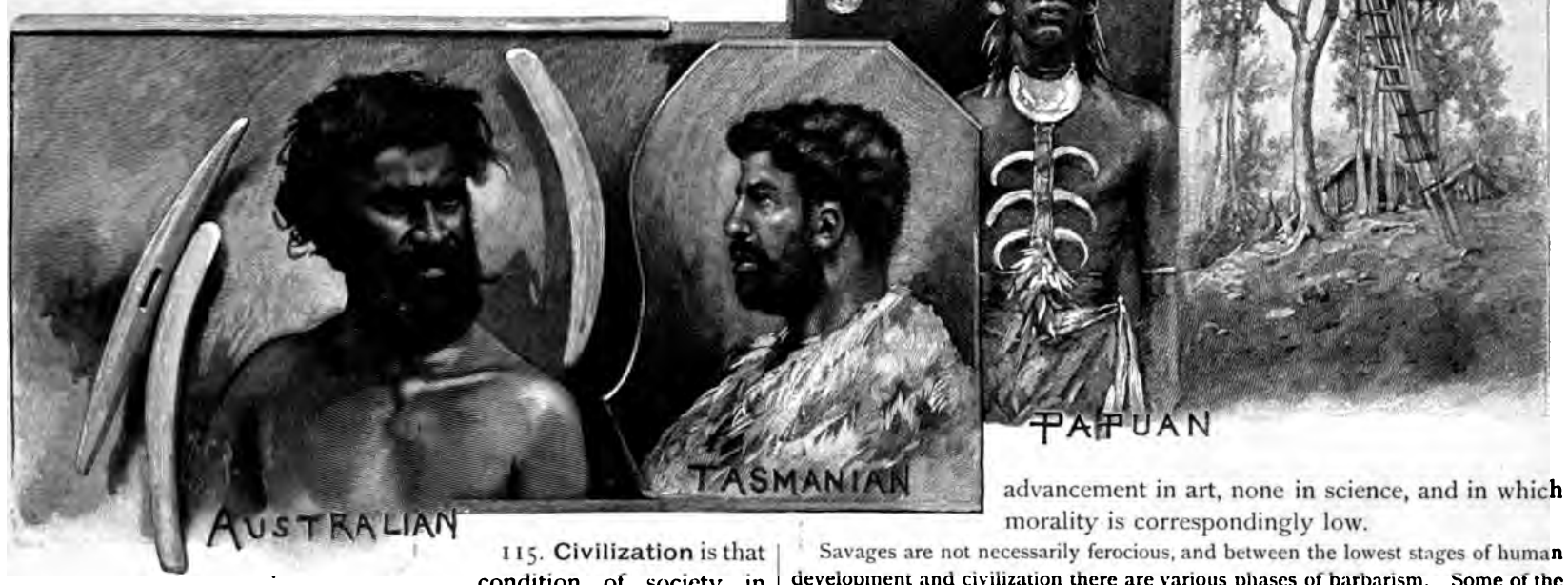
The negroes who inhabit these portions and who can withstand the climate have little intelligence, although many of them are of stalwart frame, and when carried as slaves to other hot climates, more particularly to tropical America, they have multiplied with great rapidity. This race of itself has shown no tendency toward voluntary colonization or emigration; it has spread only by compulsion, but its people have exhibited great vitality in all the warm countries to which they have been transferred.

114. **The Australian, or Negrito Race,** is characterized by its black color, long black hair, stature rather below the average, and is, as a whole, very low in the scale of intelligence.

The color is a dull or brownish black rather than the intense and shining black of the African race. The hair is usually frizzly or very curly, but in some cases is nearly straight. The head is small and narrow, and the frame is misshapen and weak.

This race inhabited Australia, Tasmania, New Guinea, and the chain of Caledonian Islands. The inhabitants of New Guinea are of a higher type, have straighter hair, and are more brown in color than the natives of Australia. The Tasmanians, who are now extinct, were the most degraded representatives of the Australasian aborigines.

It is generally believed that the lowest type of humanity belongs to this race; no other human beings have been found lower in the scale of intelligence; whole tribes are said to be so ignorant as not to be able to count more than five. Civilization has as yet made no considerable progress in any of the branches of this race.



115. **Civilization** is that condition of society in which there exist a written language, a literature, and a high state of intellectual culture, in which arts and industries are continually progressive, and in which the property, the liberty, and the lives of the people are protected by written laws.

116. **Physical Geography** is closely related to the natural development of civilization. All lands are not equally adapted to an advanced social condition of the inhabitants. The character of the climate and of the soil, the supply of water and of food, the abundance of timber and of the useful and precious metals, are all important factors in determining the prosperity of a community.

Primitive civilizations have arisen only within some of the races and in connection with proper physical surroundings. They have originated only in warm, moderately dry countries, where the climate was healthful, where trees were sufficiently plentiful for timber, but not dense enough to constitute great forests, and where a fertile soil afforded opportunity for the cultivation of food-plants.

The most fertile soils are found in valleys, on deltas, or on islands; and as the food of a civilized people is derived from agriculture, which requires an unmolested occupation of large tracts of land, natural barriers were necessary to fortify a nation against incursions of hostile tribes. All centers of original civilizations have thus been in fertile countries which could produce food and be protected from barbarous neighbors by deserts, by mountains, by water, or by some other natural features which impeded the progress of armies.

117. No people have, without help from others, emerged from barbarism to civilization in a densely forest-clad region, or in a wet, a very hot, a cold, or an unhealthful country, or where there was not a considerable variety of productions present or accessible.

The Temperate Zone seems to be best adapted to high civilization. In this climate labor is required to supply man with food and with the necessities and luxuries of life, and advancement comes to a community only as a reward of labor.

118. **Savagery,** as distinguished from civilization, is that state of society in which the people have but little intelligence, no written language, rude manners, little advancement in art, none in science, and in which morality is correspondingly low.

Savages are not necessarily ferocious, and between the lowest stages of human development and civilization there are various phases of barbarism. Some of the savage tribes subsist entirely by hunting and fishing or upon the spontaneous productions of the earth; some cultivate a few plants and domesticate certain animals. The nomads live by rearing flocks and herds.

119. **Modern Conditions.**—With the advancement in the arts and sciences, and with the appliances of modern civilization, commerce on sea has been made much more easy and safe, and land transportation by railways has changed the conditions which have heretofore controlled civilized communities.

Formerly food could be obtained only near the places where it was produced. Great cities could not grow because they could not be fed and because frequent pestilences reduced the population. Now there is, in all civilized countries, a concentration of people into cities and towns, which are supplied with food transported from distant points and which are made healthful by sanitary science.

Questions.—How does man resemble the lower animals? In what respects does he differ from them? What are the theories as to his origin? What are some of the distinguishing characteristics of mankind? How is the human species classified? Give an approximate numbering of the different races. What are the peculiar features of the Caucasian race? Where did it originate? What has been its history? How is it subdivided? What are the characteristics of the Mongolian race? Its subdivisions? What have been its tendencies toward civilization? What race originally inhabited America? How has it been affected by civilization? What are the characteristics of the Malay race? In what regions is it found? Describe the African race. The Australian race. What is civilization? Savagery? How is the former affected by physical conditions? In connection with what surroundings have primitive civilizations arisen? What changes have been effected by modern conditions?

REVIEW AND MAP QUESTIONS.

What is included in the organic world? What are some of the points of difference between crystals and cells? What are organs? What are the effects of air upon organisms? What chemical elements are essential in food? What effect does sunlight produce on plants?

Upon what do plants subsist? What kingdom supplies the food of animals? How are flowering plants propagated? Flowerless plants? What plants have net-veined leaves? Needle-shaped leaves? Where are ferns most abundant? Mosses? How are protophytes reproduced?

What are the vertebrata? Which classes of the vertebrates are warm-blooded? What peculiar metamorphosis do the batrachians undergo? How do fishes breathe? What are some of the noticeable differences in appearance among insects? How are most of the mollusks covered?

What causes produce the greatest dissimilarity in the abundance of vegetation? Where is life most abundant? At what temperature does growth cease? What regions of the earth are the most desolate? What kind of climate is best suited for an abundance of life? What are the essential requirements for the growth of forests? Where are the most extensive forests of the globe? Why are certain regions treeless? What intermediate condition exists in some places? What is the primary cause of deserts?

What is pelagic life? Abysmal life? Which is relatively more abundant in the water, animal or vegetable life? Upon what do submarine organisms depend for food? Is life most abundant near or at a distance above the sea-level? Does abundance of life necessarily imply a variety of species? When did organisms of the past first assume forms like those now existing?

How does local environment affect the natural distribution of plants and animals? By what other cause is the distribution controlled? Are organisms necessarily adapted only to their native localities? Where do annual plants flourish? Under what conditions do the stems of plants become woody? Describe the difference in the modes of growth of the exogens and the endogens.

Where is the greatest variety of species found? Where is the greatest variety of aspect in vegetation observed? What imparts the distinctive features to the vegetation of different districts? How do the plants of different regions vary in form? Where are animals and plants most gregarious?

How has civilization affected the cultivation of food-plants? How have the conditions of obtaining food been changed by modern methods of transportation? Which cereal is most used in the Eastern Hemisphere? Which are the chief coffee-producing countries?

What disagreeable result has followed the introduction of cultivated plants in new regions? What effect has the domestication of animals produced? What undesirable changes have followed the transportation of certain animals?

How do the trees of North America compare with those of Europe? Where are the most important forests of North America? What characteristic animal of North America is now practically extinct? What is the nature of the South American forests? Describe the plains of that continent. Where are the most highly-developed apes found? Which continent has the most peculiar flora and fauna? Describe the effect of the glacial period upon vegetation.

What is Ethnology? What constitutes the essential difference between man and the lower animals? Is language a natural gift? Upon what peculiarities have some of the different classifications of mankind been based? Which is the most aggressive of the races? Through what regions is the Mongolian race distributed? How did the American race receive the name of Indians? In what parts of America were the highest types of advancement displayed?

How has civilization and Christianity been received by the Malay race? What region is inhabited by the African race? By the Australian race? How have these races been affected by civilization? How is Physical Geography related to the development of civilization?

(*In answering the following questions consult the maps, pages 106–107, 112–113, and 120–121.*) Are the plant zones bounded by geographical parallels or by isothermal lines? Trace the southern boundary of the Glacial Zone. What part of Europe is included in this zone? What continent has the largest area within the limits of this zone?

In which hemisphere does the northern boundary of the cold Temperate Zone extend nearer the north pole? Why? In what zone is the greater part of the United States? What part of Europe lies in the same zone? What part of Asia is in the warm Temperate Zone? Of South America? Of Africa? Of Australia? In what zone is New Zealand?

What continent lies almost wholly in the Tropical Zone? What part of North America is in that zone? What part of South America? Of Asia? Of Australia? What large islands are in the same zone? Trace the southern limit of palms and tropical fruits. The northern limit. Where is the approximate northern limit of trees?

Where are mosses and lichens abundant? Name some of the regions of shrubby vegetation. Locate some of the extensive forests of deciduous trees. Name some of the trees found in the great forests of North America. Point out some of the treeless regions. Where are *Sequoias* and redwoods found? Name some of the regions in which orange, lemon, and fig trees flourish.

Where are the most extensive tropical forests? Name some of the important trees. Where is the date-palm found? The eucalyptus? The bread-fruit and the cocoanut? The cactus? Where are some of the tobacco regions? Where is tea raised? Coffee? Sugar-cane? Cotton? Wheat? Barley? Millet? Sorghum? Rice? Flax? Jute? Phormium? Where are spices grown?

Which kingdom, the animal or the vegetable, has naturally spread widest over the globe? How has the arrangement of the great land-masses affected the distribution of organisms? Where does the greatest similarity of kinds exist?

Trace the southern boundary of the Arctic circumpolar faunal region. What part of North America is included in the temperate region? What part of Europe and Asia belongs to that region? Locate the American tropical region. What portion of South America is in the temperate region? Where is the Indo-African region? In what region is Madagascar? What faunal region differs most widely from all the others?

Where are the largest wild animals found? In what regions are fur-bearing animals abundant? Where is the home of the musk-ox? Are the reindeer and the polar bear confined to a single continent? Name some native animal found only in North America. One found only in South America. Name some animal peculiar to Africa. What are marsupials? Where are they most abundant? Mention some of the important animals of this order. Where is the orang-outang found? The gorilla? What is the peculiarity of American monkeys? Where is the walrus found? The fur-seal? Name some of the fishes used for food.

To what race do most of the inhabitants of Europe belong? Is this race more fully represented in North America or in South America? Which part of North America is most thickly populated by this race? From what European nationalities is the white population of Central America and of South America chiefly descended? What part of Africa is inhabited by the Caucasian race? What part of Asia? What other parts of the world are occupied by Caucasians?

To what race do most of the Asiatic peoples belong? Name some of the subdivisions of the race in Asia. What branches are found in Southern Europe? In Northern Europe? In North America? What race originally inhabited the American continent? In what portions do its representatives still constitute the chief element of the population? Name and locate some of the North American tribes. Some of the tribes of South America.

What race is found in Africa south of the Sahara? In what other countries are its representatives found? Where is the Malay race most numerous? To what race do most of the Australasian natives belong?

THE UNITED STATES.

I. Position, Extent, and Shape.

1. As now constituted, the **United States** consists of two portions of North America detached from each other, and the islands adjacent to these portions. The detached territory of Alaska will more conveniently be considered by itself.

The United States proper occupies the central part of the continent. This great country is bounded by the Atlantic Ocean on the east, and by the Pacific Ocean on the west. The chain of great lakes forms a portion of the northern boundary, and the Gulf of Mexico a part of the southern. The rest of the boundaries are arbitrary lines, and not geographical features.

This main portion of the United States extends through 24½° of latitude, or from near the Tropic of Cancer to the 49th parallel, and through 57° of longitude, from the 67th to the 124th meridian. A line drawn from ocean to ocean near the 40th parallel would have a length of about 2650 miles, and one drawn on the 98th meridian of longitude from the Rio Grande to the northern border would have a length of about 1600 miles.

The approximate area of the country (excluding Alaska) is a little over 3,000,000 square miles, of which the land area is about 2,970,000, and the inclosed waters (not including the great lakes) 50,000, square miles.

2. The **Coast-Line** of the United States is much less indented than is that of Europe. It has but few bays extending far inland, and, correspondingly, few projecting peninsulas; but there are many small bays affording harbors and many navigable rivers giving access to the sea.

The coast of Maine has numerous indentations, not of very great extent, but large enough and deep enough to furnish abundant harbors; the harbor of Portland is a good example. At the head of Massachusetts Bay lies the commodious harbor of Boston; between this and New York there are several smaller harbors once of great commercial importance, and still enjoying considerable trade.

Long Island Sound, 120 miles long and about 25 miles wide, is the route of much commerce; it communicates with the Atlantic at its eastern, and with the harbor of New York at its western, end.

The harbor of New York, the largest and best situated for commerce of any on the west coast of the Atlantic, lies at the mouth of the Hudson River and communicates with Long Island Sound.

South of this are Delaware and Chesapeake bays, each affording a number of harbors. Still farther south there are numerous small and several large harbors, more particularly those of Charleston and Savannah.

On the Pacific coast there are but three bays of much value to commerce: the harbor of San Diego in the extreme southern part of California, the bay and harbor of San Francisco, and Puget Sound. The irregular bay of San Francisco constitutes one of the largest harbors of the world; it is comparatively landlocked, and communicates with the ocean through the narrow and deep channel known as the Golden Gate, lying between high headlands. Puget Sound is an exceedingly irregular body of water opening into [illegible] connecting with the Strait of Juan de Fuca; it is estimated to have more than 1000 miles of coast-line, and abounds in beautiful and commodious harbors.

The Golden Gate and Harbor of San Francisco.

The great indentation of the Gulf of Mexico is a border sea of the Atlantic, and is no more especially related to the United States than to Mexico, but is a geographical feature of vast importance to the country. It has a depth of more than 2000 fathoms, and from its position not only favors commerce, but modifies the climate of all the States lying east of the Mississippi River.

3. **Capes.**—There are many projections of land known as capes; and although some of these projections are slight, yet they are convenient geographical points which serve as guides to the mariners who sail along the coast.

Cape Ann and Cape Cod mark the entrance of Massachusetts Bay; Montauk Point is the eastern extremity of Long Island; Sandy Hook marks the entrance of New York harbor; Cape May and Cape Henlopen, the entrance of Delaware Bay; Cape Charles and Cape Henry, that of Chesapeake Bay; Cape Hatteras (a low, sandy cape and the dread of mariners) is the most projecting part of North Carolina; and Cape Sable forms the south-west point of the peninsula of Florida.

On the Pacific coast, Point Conception, near Santa Barbara, Point Arenas, north of the Bay of San Francisco, Cape Mendocino (the most western portion of California), and Cape Flattery, at the extreme northwestern part of Washington, are the capes of most interest.

4. **Islands.**—There are numerous small islands near the mainland, more especially along the Atlantic coast. They are all of them typical continental islands, and are either extensions of the continental structure or sand-spits outside a low coast.

There are many islands along the coast of Maine, mostly small and rocky, of which Mount Desert is the largest and is best known as a summer resort. Off the coast of New Hampshire is the group of small rocky islands known as the Isles of Shoals, noted from the earliest settlement of the colonies for their mackerel fisheries.

Long Island, 120 miles long, is the largest of the islands of the United States, and forms one of a series lying south of New England; to the east of it are Gardiner's Island, Block Island, Martha's Vineyard, Nantucket, and a few others of smaller size; and to the west are Staten Island and Manhattan Island, not only noticeable as geographical features, but of great importance because of the populous settlements situated upon them.

South of Chesapeake Bay there are numerous low islands with shallow sounds or channels behind them, but of little geographical importance or interest. On the Pacific coast there are but few islands; the Santa Barbara group lying west of Southern California and the small rocky Farallones lying off the Golden Gate are almost the only ones.

Questions.—Of what two portions does the United States consist? In what part of North America is the main portion situated? Through how many degrees of latitude and longitude does it extend? What is its area? How does the coast-line compare with that of Europe? What is the character of the harbors on the Atlantic coast? In what respects is the Gulf of Mexico important? Name some of the capes on the eastern coast. On the western coast. Along which coast are the islands most numerous?

II. General Surface Structure.

5. The two dominant mountain-systems of North America attain their greatest development within the United States and determine all the grander features of surface-relief.

The **Cordilleras** in the west constitute the primary axis; the **Appalachians** in the east, the secondary axis. These are so disposed as to make several drainage areas, although the structure of the country is, as a whole, very simple.

6. The **Appalachian System,** although of secondary geographical importance, is first in political and historic interest.

This system consists of numerous ridges and groups extending from Maine south-westerly to Alabama and Georgia; the several parts are known by different local names. (See p. 33.) It consists of numerous flexures or wrinkles in the earth's crust (see p. 13, fig. 3) variously bent and broken; these flexures are more irregular and more broken in the northern part, and particularly in the White and Green mountains, which have a type of scenery unlike that farther south.

Two peculiar and very important valleys pass entirely through this system—that of the Hudson River and Lake Champlain, and that of the Mohawk Valley.

These depressions or valleys divide the Appalachian System into three distinct sections, which would appear as large islands if the waters of the ocean should rise but a few hundred feet.

These are—(*a*) the New England section from the Gulf of St. Lawrence to the Hudson River; (*b*) the Adirondacks between Lake Champlain and the Mohawk Valley; and (*c*) the southern section from the Mohawk and Hudson rivers to Northern Georgia and Alabama.

These two passes through this mountain-system have played an important part in the history and settlement of the country. Railroads and canals now pass through both, and they are among the more important natural avenues of commerce on the continent. Until railroads crossed the Appalachians farther south, they were the chief outlet of the produce of the West to the Atlantic coast.

7. The **New England Section** contains the various mountain-groups of Maine, of which Katahdin (5200 feet) is the highest, the White Mountains of New Hampshire (Mount Washington, 6286 feet), and the Green Mountains of Vermont (Mount Mansfield, 4430 feet).

These mountains of New England are, geologically, very old; they are rounded in outline (see p. 15), and abound in picturesque scenery.

There have been no extensive volcanic eruptions covering the older rocks, but in Southern New England there are many elevations of *trap*, rising in precipices and constituting picturesque features of the landscape. Mount Holyoke in Massachusetts, Mount Carmel and the Hanging Hills in Connecticut, and the Palisades on the Hudson are examples. (See p. 13, also p. 19.)

8. The **Adirondack Section** consists of several ranges trending north-easterly and south-westerly. Mount Marcy (5379 feet) is the highest peak.

This region is especially noted for its numerous and beautiful lakes and picturesque scenery. Its magnificent forests constitute the "Wilderness" of New York. There are extensive iron-mines in the eastern, and quarries in the southern, portion.

9. The **Southern Section** is very much greater in extent, extending from the Hudson and Mohawk rivers to Alabama. The parallel ridges are better defined and more numerous, more than twenty having been enumerated by geologists in Pennsylvania.

Belonging to this portion may be mentioned the Catskill Mountains in New York, near the Hudson River, especially noted for their scenery; south of these the Shawangunk Mountains, between the Hudson and Delaware rivers; the Kittatinny, or Blue Mountains, to the north and west of the Cumberland Valley in Pennsylvania; the Alleghany Mountains, between the Susquehanna and upper Potomac, passing from Pennsylvania into Virginia.

Between the Alleghany and Blue mountains are many ridges separated by narrow and picturesque valleys. The Cumberland Mountains of Eastern Kentucky and Tennessee, the Blue Ridge extending from Virginia southward to South Carolina, and the Great Smoky Mountains from Virginia to Georgia, are the best known. Mount Mitchell, in North Carolina (6688 feet), is the highest of the Appalachians.

Between these mountain-ridges are some exceedingly beautiful longitudinal valleys. (See p. 29.) The Shenandoah Valley between the Shenandoah Mountains and the Blue Ridge is the most noted.

10. The **Atlantic Coast-Plain** extends from the eastern base of the Appalachians to the sea. It varies in width; in some places in New England it is as much as 50 miles wide, narrowing in Maine, and again at New York, to a few miles, thence widening southward until in the latitude of Cape Hatteras it is more than 200 miles wide. This strip of coast is generally sandy near the sea, rising in a gentle slope and with a different soil farther inland near the mountains.

In Southern New England this plain is broken by frequent hills. It is sandy, but in general fertile, especially in New Jersey, becoming more swampy near the sea in the Carolinas. From Virginia southward it consists of two distinctly-marked regions, the lower or coast region proper, and the more elevated region known as the Piedmont Plain, or sometimes the "Piedmont Plateau."

The coast-region is rarely more than 100 feet above the sea, and has a sandy soil covered with pine forests (locally, called the Pine Barrens). Large swamps occur near the coast, of which the Cypress Swamp in Delaware, the Dismal Swamp on the southern borders of Virginia, the Alligator Swamp between Albemarle and Pamlico sounds, the Green Swamp west of Cape Fear River, the Okefinokee Swamp in Southern Georgia, and the Everglades in Florida, are the best known.

The middle country, or "Piedmont Plateau," rises in a gentle slope from the coast-district, varying in elevation from a few hundred to more than 1000 feet, diversified by hills, with numerous intervening valleys. The soil is productive, the scenery picturesque, and the climate delightful.

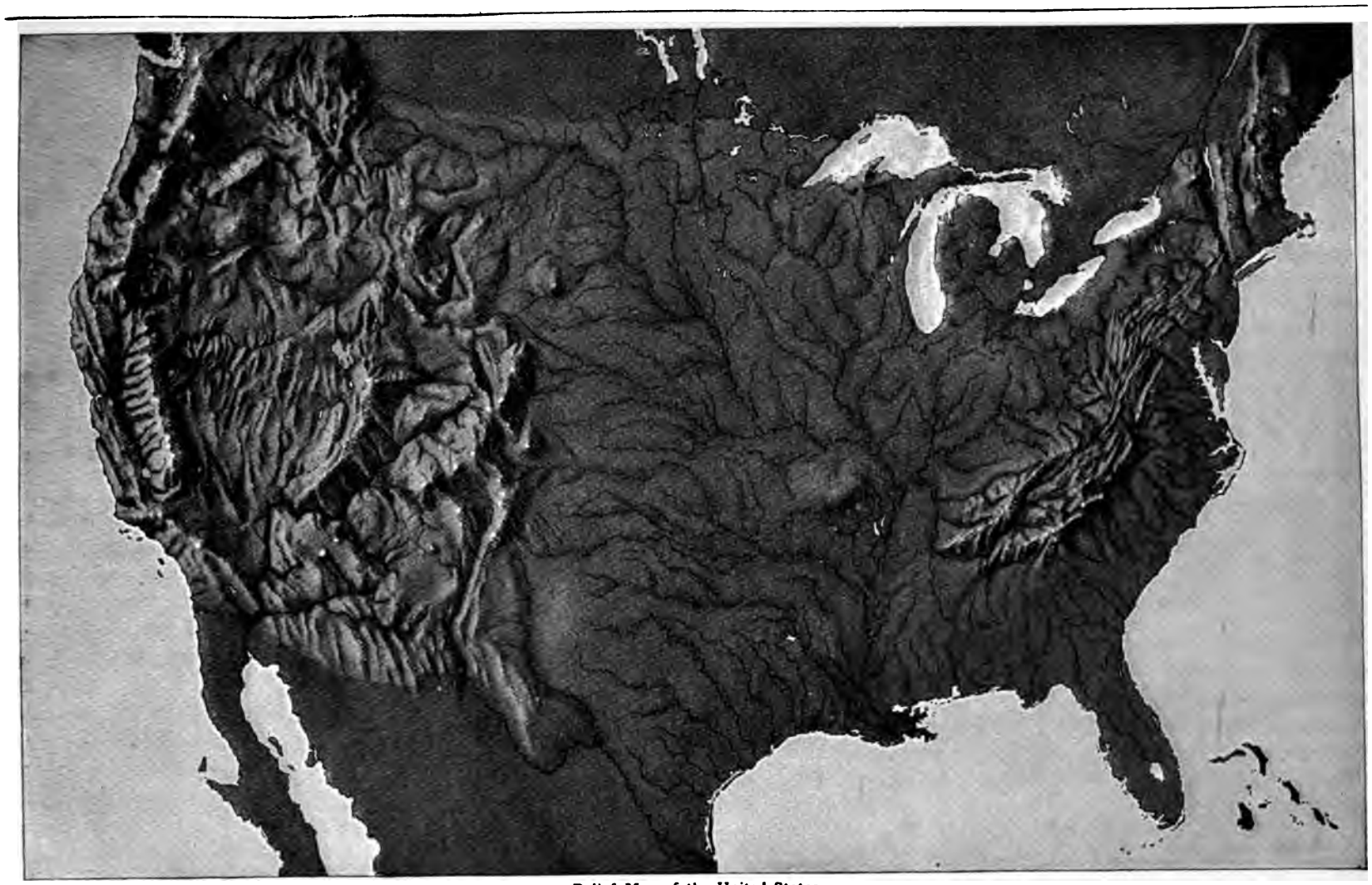
The dividing-line between these two regions is marked by a somewhat abrupt slope or terrace, and in the streams by rapids, which interrupt navigation and give rise to numerous towns. Trenton, Fredericksburg, Richmond, Raleigh, Columbia, Augusta, and Macon are related to this change of slope.

11. The **Cordilleran System** of the west is but a part of that great system which extends from Cape Horn to the Arctic Ocean. (See pp. 32, 33). This grand and complex system, consisting of mountains, plateaus, and valleys, attains its greatest width near the 40th parallel, where from Cape Mendocino to the eastern base it is more than 1000 miles wide.

For convenience of description, that portion of this system within the United States is divided by Professor Whitney into six regions. These divisions are (1) the Rocky Mountains, (2) the Great Basin and the Basin Ranges, (3) the Northern or Columbian Plateau, (4) the Southern or Colorado Plateau, (5) the Sierra Nevada and Cascade Ranges, and (6) the Pacific Coast Ranges.

12. The **Rocky Mountains** form the eastern ranges of the Cordilleran System. (See p. 33.) These consist of a considerable number of more or less parallel chains or ranges which are disposed in two great groups, the southern and the northern.

Between these two is a high plateau region, over which the Union Pacific Railway passes at an altitude of about 8000 feet. The southern group is the higher, lying mostly in Colorado; within this State



Relief Map of the United States.

thirty-seven peaks have been measured which are more than 14,000 feet high. Sierra Blanca (14,464 feet) is the highest; Long's Peak (14,271 feet) and Pike's Peak (14,147 feet) are conspicuous landmarks from the plain and are perhaps the best known, but Gray's Peak (14,341 feet) and mounts Lincoln (14,297), Yale (14,187), Harvard (14,375), and Uncompahgre (14,235) are familiar names.

Nowhere else on the globe is there such a large number of high peaks reaching so nearly the same altitude, and having in the entire group no one peak towering high above its fellows.

Between these ranges, and variously enclosed within them, are numerous elevated valleys or plateaus called *parks*. San Luis Park, South, Middle, and North parks, lying at altitudes of from 6000 to 10,000 feet, are the most noted, but there are many others, some of which are widely known because of their beauty and picturesque surroundings.

The northern group of the Rocky Mountains has its greatest development in Wyoming. This group is wilder, more rugged and more difficult of access than the southern, although not so high, scarcely half a dozen peaks having been measured which are above 13,000 feet in altitude.

The Wind River chain is the culminating mass, and in it are the extreme head-waters of the three great river-systems of the United States—the Mississippi, the Columbia, and the Colorado systems; Fremont's Peak (13,790 feet) is the highest point.

To the west of the Wind River Mountains is the limited but high and picturesque Teton group, of which The Three Tetons are the most noted. The highest of these is Mount Hayden (13,691 feet). (See illustration, p. 29.)

The Rocky Mountains abound in grand scenery, some of which is especially famous. These are to a great extent mountains produced by fracture (see p. 29), and eruptive volcanic material forms only an unimportant feature.

In the north-western part of Wyoming there is the Yellowstone Park, famous for its hot springs, its geysers, and its sublime scenery.

The Black Hills, on the borders of South Dakota, belong to the Cordilleran System, but are detached from the Rocky Mountains and from all other chains.

13. The **Great Basin** is the name given to a region enclosed within this system and having no drainage to the sea. (See p. 49 and p. 133.)

This embraces an area of about 217,000 square miles; it is rudely triangular in shape, the base at the north, and tapering southward. The Wasatch Mountains form the most obvious part of its eastern rim, and the Sierra Nevada the western. The region extends southward beyond both of these, with the apex of the triangle in Lower California.

Within this area are numerous ranges of mountains having a general north-and-south direction. The whole region has a dry climate. Most of the rain falls upon the mountains, some of which have limited forests, but most of them are naked of forest vegetation.

The valleys between these ranges are mostly barren, and some of them are actual deserts. Some of these valleys are occupied by salt lakes; others, by

saline swamps; others still are salt or sandy deserts. Those of the northern portion have an elevation of 4000 or 5000 feet above the sea; those southward gradually descend until some lie below the level of the sea. Death Valley, lying near the eastern borders of California, and which is the sink of the Amargosa River, is said to be between 200 and 300 feet below the sea-level. Another and larger depression in the San Bernardino Desert, near the southern boundaries of California, known as the Sink of San Felipe, is variously reported to be from 60 to 130 miles long, and the lowest portion is said to be 320 feet below the sea-level.

While most of the valleys in the Great Basin are barren, there are some of great fertility, and numerous others may be made fertile by irrigation, although, as a whole, the region may justly be called a barren one.

The mountain-ranges of the basin also increase in elevation northward. The most elevated range is called the East Humboldt; its highest peak is Mount Bonpland, 11,321 feet, the highest of all the basin-peaks. The West Humboldt range is also a conspicuous one near the western side of the basin; its highest point is Star Peak, 9925 feet. The Washoe Mountains are not so high, but are famous all over the world for their silver- and gold-mines. Farther south, and near the western border, the Inyo Mountains are conspicuous.

14. The **Northern, or Columbian, Plateau** lies to the northward of the Great Basin, between the Rocky Mountains and the Cascade Mountains; it is drained by the Columbia River and its tributaries. Much of this plateau is covered with volcanic-erupted material (see p. 21), into which the rivers have eroded deep channels.

The Shoshone Falls, notable among the great waterfalls of the world, and probably next to Niagara in grandeur, are produced where the Snake River with its vast volume of water tumbles over a stratum of lava, making a fall more than 250 feet high. The Black Cañon below the falls is in places 600 feet deep, eroded in the dark-colored, volcanic rock.

The southern portions of this plateau are, as a whole, dry, but some of the northern portions, more particularly Eastern Washington, are very fertile. The Blue Mountains in Oregon and the Owyhe in Idaho are the chief mountain-ranges.

Rock-Forms in Monument Park, illustrating Atmospheric Erosion.

15. The **Colorado Plateau** lies south of the Great Basin, between the Rocky Mountains and the Sierra Nevada, mostly in Southern Utah and Northern Arizona. It consists of numerous elevated plateaus, now dry and barren, but which once evidently had much more water, the rivers having eroded deep channels. The erosion of this region is perhaps the most remarkable in the world. The Colorado River and its branches have in places cut cañons a mile deep; even in portions now dry the naked rocks have been wrought by atmospheric agencies into extraordinary forms. (See pp. 12 and 47.)

16. The **Sierra Nevada and Cascade Region** is perhaps the most interesting portion of the Cordilleran System; it has the highest peaks, the grandest scenery, and with it is associated more of economic and political interest than pertains to any other mountain-region of the country.

Mount Whitney (14,898 feet) is the culminating point. This portion of the chain is so continuous and lofty that for 200 miles northward from Walker's Pass there is no pass less than 11,000 feet above the sea-level, and the scenery is correspondingly grand. Yosemite Valley is perhaps the most famous in this respect, but other portions nearly equal it in beauty.

The gold-region of California lies mostly on the western slope of these mountains between latitude 37° and 40°. Gold is widely distributed in the Cordilleran System, but by far the greater portion of the gold of California has come from this region.

The Central Pacific Railway crosses the chain between latitude 39° and 40° at an altitude of about 7000 feet; south of the pass through which the road extends all the high peaks are of granite or metamorphic rock; north, all the higher points are volcanic, forming perhaps the most remarkable group of extinct volcanic cones on the globe.

The Cascade Range is, in reality, only a prolongation of the Sierra Nevada, the group of volcanic peaks beginning in the one and extending throughout the whole length of the other. Mount Shasta, Mount Pitt, Mount Hood, Mount St. Helen's, Mount Adams, and Mount Rainier (or Tacoma) are the best known; their sharp, snow-clad summits, towering far above the surrounding mountains into the clear sky of that region, are especially sublime objects in the landscape.

Three transverse valleys cut their way through the volcanic portion of this chain—those of the Pitt and Klamath rivers in California, and farther northward that of the Columbia River. The passage of the Columbia through the Cascade Range in a gorge more than 3000 feet deep is a feature of especial grandeur.

The peninsula of Lower California is probably the southern extension of this belt of fracture in the earth's crust.

17. The **Coast-Ranges** of California and Oregon consist of numerous chains; northward from Cape Mendocino they are more nearly parallel to the coast than southward. North of Point Conception these mountains come down to the sea, leaving, as a rule, no coast-plain between their bases and the ocean. Moreover, there are few gaps, and therefore but few harbors. The Bay of Monterey, which is a broad open harbor, and the Golden Gate, which is the entrance of the commodious Bay of San Francisco, are the chief breaks; north of this bay there are no commodious harbors until Puget Sound is reached.

Interspersed among the various branches of these Coast Ranges, particularly in California, there are numerous valleys of considerable extent. Some of these, on account of their great fertility, their picturesque beauty, and their genial climate, are already widely celebrated, and others are justly becoming so.

18. Along the eastern base of the Cascade Range and the Sierra Nevada is a series of plains, plateaus, and valleys. In Washington is the plateau of the Columbia; in Oregon is the valley of the Des Chutes River; in California and on its northern borders is the basin occupied by the Klamath lakes. Southward, from Lake Tahoe to Lake Mono, extends a plateau 6000 feet or more above the sea; from this point toward the south it declines in height until a portion of the San Bernardino Desert is below the sea-level, and the Gulf of California appears to be the southern extension of this line of depressions. Most of these valleys are of limited fertility.

19. Between the Coast Ranges and the Sierra Nevada and Cascade Range there is another series of valleys. These are all of good size, and several of them are very fertile and remarkably picturesque. The northern part of this depression is occupied by Puget Sound; a plain or valley extends southward across the Columbia and up the Willamette; south of this is a chain of basin-like valleys; low hills separate the Willamette Valley from that of the Umpqua; higher hills separate this from the basin-like valley of Rogue River; the low Siskiyou Mountains separate this from the broader Shasta Valley on the Klamath River; and higher mountains separate this in turn from the Great Central Valley of California.

This last is about 400 miles long and 30 to 60 miles wide, of great fertility and beauty. It is drained by the Sacramento and San Joaquin rivers, which unite and break through one of the Coast Ranges at the Strait of Carquinez to the Bay of San Francisco.

20. **The Great Plains.**—Along the eastern base of the Rocky Mountains the western highland of the United States has an average elevation of at least 5000 feet. The plateau then slopes gradually toward the east till it merges into the prairie region which borders the Missouri and Mississippi rivers. The descent is so imperceptible that the slope is known as the Great Plains.

Although this entire region belongs to the Great Central Valley, which lies between the Cordilleras and the Appalachians, its western portion differs in so many respects from the more fertile land of the river-valleys farther east that it is customary to make a distinction between the two sections.

21. The Great Plains extend northward in an irregular belt from the Guadalupe Mountains in Texas, and are parallel to the ranges of the Rocky Mountains. This belt, which reaches approximately from the 105th to the 95th meridian, is nowhere less than 500 miles in breadth.

22. When the Rocky Mountains were first uplifted, they were much higher than at present. The waves of the sea which dashed against their eastern base (see p. 134), and the streams which flowed down their slopes, slowly reduced their height. The eroded material spread over the bed of the ocean formed the rocks, which were subsequently elevated and which cover this long incline toward the east.

The area constituting the Great Plains appears to have resulted from three successive upheavals, and is naturally divided into as many characteristic sections. The surface-rocks of the first section, especially at the south, are very largely of igneous origin, and along the eastern edge they descend in many places precipitously to the second section, known as the "High Plains." This region consists of softer material through which the rivers have cut cañons. In the third division the land slopes from a height of from 3000 to 4000 feet to the level of the Missouri and the Mississippi. This last section is the most extensive, and, though it is, like the others, the result of an uplifting of the crust, it has more the general appearance of an alluvial deposit.

23. While the general descent is so slight as to be scarcely perceptible, the surface is far from level. In the middle plain, particularly between the streams, the land is broken by elevations and depressions of great variety. The lines of upheaval are sometimes parallel to the neighboring mountain-ranges, but they are frequently disposed at right angles or obliquely to the general trend.

Parts of this region were once occupied by lakes, which have since disappeared (see p. 134), and the land which once formed their beds abounds in the fossils of extinct animals. Near the Cimarron River is an extensive salt-plain produced by the evaporation of one of these ancient lakes.

The rivers which traverse the Great Plains are deep and rapid in their upper courses among the mountains and in the upper plains, where they have narrow but fertile bottom-lands, but in the lowest plain the currents are slow, and the beds are wide, shallow, and sandy. The bottom of these streams consists of alluvial deposit underlaid with sand. During the rainy season, when the flow of water increases, this alluvial earth is removed and the sand is washed up; the rivers then present the appearance of streams of flowing sand; as it is sometimes paradoxically expressed, they "rise downward at high-water," and their courses are continually shifting.

The drifting sands or dunes form another noticeable feature of this region. They usually extend in an easterly direction in almost unbroken lines and often follow the water-courses. They vary in shape and in width; sometimes they appear as a succession of low hills, and sometimes they lie in long level masses; they are often but a few feet wide, but they sometimes attain a breadth of many yards.

24. The **Great Central Valley,** or the area which drains mainly into the Gulf of Mexico, occupies the whole middle portion of the country between the two great mountain-systems. This valley is a part of the continental depression which extends from the Gulf of Mexico to the Arctic Ocean. East of the Great Plains and west of the Appalachians the land is smooth, and is broken by no very noticeable elevations.

Along the northern boundary of the United States and in the region of the Great Lakes there is a gentle rise which separates the different drainage-areas. By far the greater part of the Central Plain is drained by the Mississippi and its tributaries, and by a few other smaller streams, into the Gulf of Mexico. In the north, that part of the valley which lies within the territory of the United States is drained by rivers which reach the Atlantic Ocean by way of the St. Lawrence River or Hudson Bay.

A range of hills, known as the Ozark Mountains, which have an altitude of from 500 to 2000 feet, marks the only other important departure from the uniformly level character of the valley. This low but somewhat extensive elevation reaches from the southern part of Missouri into Indian Territory.

In the northern part of the valley the land is higher than in the southern expanse, and the river-banks frequently form bluffs which are sometimes a few hundred feet in height.

The belt at the eastern base of the Rocky Mountains is mostly too dry for agriculture, although affording extensive pasturage; but the fertile prairies, rolling hills, and rich bottom-lands of the central and eastern portions of this area make it undoubtedly the most important basin in the world as regards agricultural wealth.

Questions.—What is the general character of the Appalachian System? What valleys cut through the system? Into what sections is it divided? Describe the New England section. The Adirondack section. The southern section. What are some of the characteristics of the Atlantic coast-plain? Into what six sections is the Cordilleran System divided? What name is given to the eastern ranges? Name some of the peaks in the southern group of ranges. In the northern group. Where is the Great Basin? Describe its general character. Where is the Columbian Plateau? What is the nature of its surface-rocks? Where is the Colorado Plateau? What are some of the features of the Sierra Nevada and the Cascade Range? By what valleys is this chain cut? Where are the Coast Ranges? Describe the country between the Coast Ranges and the higher mountains. Where are the Great Plains? What is the nature of the surface? What is included in the Great Central Valley?

III. General Physical View.

25. The position of the United States, the character of its coast-line, and the predominant features of its surface-relief already enumerated may be more readily comprehended in connection with the accompanying physical map.

The situation and extent of the drainage-areas, the direction and course of the rivers, and the distribution and location of the lakes, as described in the pages following, should be studied with reference to this map. It should also be consulted in considering the distribution of the plant and the animal life of the country, and in contemplating the disposition of the various mineral resources.

The heights of land and the depths of water are represented by a scheme of coloring which is explained in the Key. The names of plants are printed in black and those of animals in red. In each case Italic type has been selected, while for minerals a Gothic or block-letter is employed, and capitals are used for the whole word, which is printed in red.

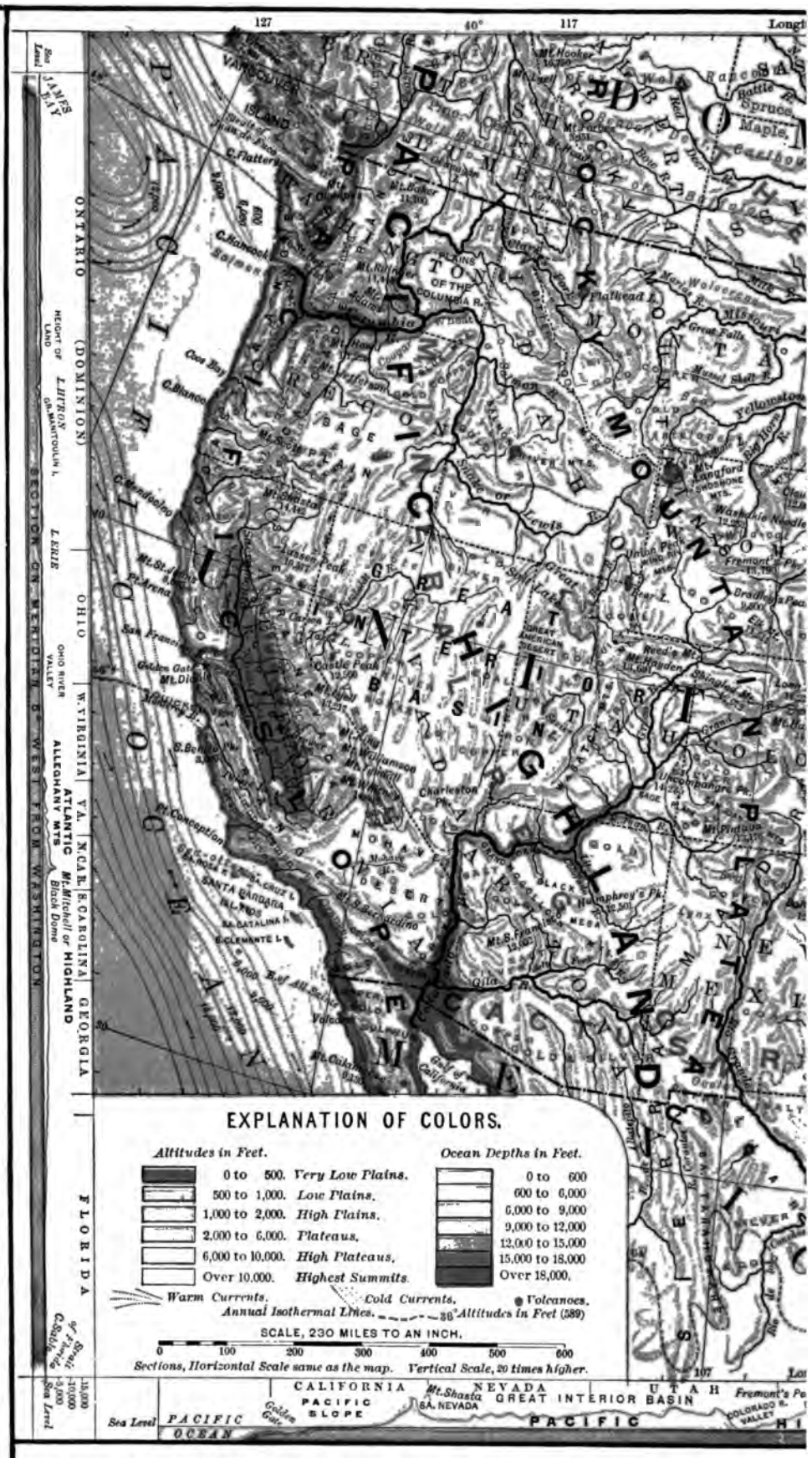
26. By contrasting the Atlantic and the Pacific coasts, the broken and irregular nature of the former is at once apparent, and the depths of the adjacent waters show that the shore of the Atlantic coast is shelving as compared with the bolder and often precipitous western border.

Between the Appalachian Mountains and the ocean the coast plain is seen to extend with increasing width as it approaches the Gulf of Mexico, where it joins the lowland that encircles that great arm of the Atlantic. To the east of the mountains the foot-hills descend gradually to the level of the plain, and to the west the elevated region merges into the prairies and lowlands of the Mississippi Basin.

27. West of the great river, the boundary between the low bottom-lands and the eastern edge of the Great Plains is neither clearly defined nor regular, and the ascent to the base of the Rocky Mountains is gradual. In Colorado occurs the noted group of lofty mountains, in which many of the peaks have an altitude of more than 14,000 feet. To the south lies the Colorado Plateau, through which the course of the Colorado River and its branches may be traced, and to the north are the Wind River Mountains, in which so many great rivers have their head-waters.

Between the Wasatch Mountains and the Sierra Nevada is the Great Interior Basin, and farther north are the Plains of the Columbia River. There are no extensive plains on the Pacific slope, and in many places the Coast Ranges extend to the sea.

28. The rather gentle elevation separating the Mississippi Valley from that of the St. Lawrence is graphically represented on the map, as is also the "Height of Land" which divides the St. Lawrence System from the rivers flowing north, and it will be seen that the lake region lies in a broad belt encircling Hudson Bay. (See p. 52.)



Questions on the Map.—Along what part of the Atlantic coast of the United States is the most extensive area of shallow water? Along what part of the Pacific coast is the line of 600 feet of depth farthest removed from the shore? Where is Cape Hatteras? Cape Flattery? What is the most southern cape of the United States? The most western?

Where are the White Mountains? The Adirondacks? The Cumberland Mountain
Mountains? The Wasatch Mountai
River Mountains? The Uintah M
Bitter Root Mountains? The Laran
Locate and give the heights of the f
Uncompahgre Peak, Mount Washingt
Mount Harvard, Mount Rainier, Mou
mont's Peak, Mount Marcy, Mount

Ozark Wind The tains? eaks: Peak, Fre- Mount

Katahdin, Mount Hayden, Mount Shasta, Long's Peak, Mount Baker, Blanca Peak, Mount Hood.

Into what body of water does the St. Lawrence River flow? The Connecticut? The Delaware? The Savannah? The Chattahoochee? The Mississippi? What rivers flow into Chesapeake Bay? What river forms part of the boundary between Mexico and the United States? What rivers between this and the Mississippi flow into the Gulf of Mexico? Into what body of water does the Colorado River flow? The Columbia? What rivers empty their waters into San Francisco Bay?

Which is the largest of the Great Lakes? The smallest? Where is the head of Lake Michigan? Of Lake Champlain? Locate Great Salt Lake. Yellowstone Lake. Lake Tulare. Lake Tahoe.

Where is the great cotton region? The mineral region? The corn region? The wheat region? The cactus region? The lumber region? The tobacco regions? The pasture region?

Name some of the important animals and tell where they are found. Some of the important plants. Name five different regions in which coal is found. Five gold regions. Five silver regions.

IV. Rivers and Lakes.

29. No other country of the Temperate Zone is so favored by the number and length of its navigable rivers and the abundance and size of its lakes as is the United States.

The general surface structure of the country determines the length and slope of the rivers, and the climate regulates the amount of water which they carry.

Most of the larger streams rise north of the 40th parallel of latitude, and north of this same line is one of the most notable lake-regions of the world. For convenience, the rivers may be classified and described in the following divisions: the St. Lawrence System; rivers flowing into the Atlantic Ocean; rivers flowing into the Gulf of Mexico; rivers flowing into the Pacific Ocean; and the rivers of the Great Basin.

30. The **St. Lawrence System** is especially important to the United States, not so much for the St. Lawrence River itself as for the chain of Great Lakes which it includes. The tributaries of this system which lie within the borders of the United States are rather insignificant, but the chain of lakes is the most extensive in the world. (See p. 53.)

To the southward of Lake Erie, and to the south and west of Lake Michigan, the divide between this system and that of the Mississippi is a level region rather than a chain of hills, and is exceedingly low; in places it rises less than 25 feet above the surface of Lake Michigan.

The Great Lakes are very deep; they are navigable by the largest craft, and they are of great importance to the commerce of the country. The coast-line of the United States upon these lakes is estimated at more than 3000 miles.

Besides the Great Lakes already mentioned, there are numerous smaller bodies of water belonging to this system. Lake Champlain and Lake George east of the Adirondacks, a number of small but beautiful lakes on the northern slopes of those mountains, the lakes of Central New York, and those of Northern Michigan, are well known, and some of them have much celebrity.

31. The **Rivers Flowing into the Atlantic Ocean,** south of the St. Lawrence, rise upon or among the ranges of the Appalachian System. Until they reach the terrace dividing the highlands from the low coast-district they are, as a rule, rapid and shallow; but in the lower and flatter country their currents are more quiet, their waters deeper, and they are in general navigable.

In New England, the Penobscot and Kennebec in Maine, the Merrimac in Massachusetts, the Thames and Connecticut in Connecticut are the chief; of these the Connecticut is the longest and the most important.

The Hudson River, which takes its rise in the Adirondack Mountains and breaks through the intervening ridges amid scenery of great natural beauty, and which empties its waters into New York Bay, is, in commercial importance, the principal river of the Atlantic coast. At its mouth is the great harbor of New York. It is navigable to Troy, a distance of 160 miles; it is connected with the chain of the Great Lakes by the Erie Canal and with the St. Lawrence and Lake Champlain by the Champlain Canal. Thus, an unbroken water-communication exists between the Great Lakes, the St. Lawrence, and the city of New York.

The Delaware River rises in the Catskills, cuts its channel through the ridges of the Blue Mountains at the Water Gap, and flows into Delaware Bay; it is navigable to Philadelphia. The Susquehanna rises in Central New York, and with its tributaries traverses some *of the most beautiful valleys* of the southern part of that State and of Pennsylvania, discharging its waters into Chesapeake Bay; it is navigable only for small craft. The Potomac rises in Eastern Virginia and breaks through several ridges, ultimately reaching Chesapeake Bay. It receives the Shenandoah and several important branches which lie in the longitudinal valleys of Virginia and of West Virginia, and minor tributaries from Maryland; it abounds in picturesque beauty, and its passage through the Blue Ridge at Harper's Ferry is especially noted. In its lower course it passes by Georgetown, Washington, and Alexandria; it is navigable to Washington, below which point it is a broad and majestic river.

The James River of Virginia flows past Richmond and empties its waters into the Hampton Roads. In the Carolinas there are the Roanoke, the Neuse, the Cape Fear, the Great Pedee, and Edisto rivers, all of which are navigable for some distance from the sea. The Savannah, which forms the boundary between South Carolina and Georgia, is a large river and navigable for a considerable distance. The St. John's River is the chief river of Florida, and is navigable far into the interior.

A multitude of lakes belong to these various rivers, but none of them are very large. (See p. 52.) There are more than a thousand in New England, especially in the northern portion, of which Moosehead Lake in Maine and Winnipiseogee in New Hampshire are among the largest. There are also a number of lakes in the Adirondacks about the head-waters of the Hudson.

South of latitude 42° there are few lakes on the Atlantic slope; wherever there are mountains in a rainy region there are always some lakes, but there are curiously few in the southern Appalachian region; in Florida there are several lakes, of which Okechobee is the largest.

32. **Rivers Flowing into the Gulf of Mexico.**—The Mississippi is the chief stream emptying its waters into the Gulf of Mexico, and is one of the great rivers of the world. The basin drained by it and its tributaries is second in extent only to that of the Amazon; from the great falls of the Missouri to the Gulf of Mexico, a distance of 3000 miles, navigation is uninterrupted. With its tributaries it is the longest stream of the world and has the greatest extent of navigable waters. (See p. 45.)

Of its eastern tributaries, the Ohio, rising in the Appalachian Mountains of Pennsylvania and of West Virginia, is the most important, and flows past many large cities, such as Pittsburg, Wheeling, Cincinnati, and Louisville; its volume of water is greater than that of any of the other tributaries.

The upper Mississippi proper has its source in a broad, level country abounding in numerous lakes. The Missouri rises in the Rocky Mountains, its head-waters lying adjacent to those of the Columbia and Colorado rivers, and it has a course of 2900 miles; it is navigable for a distance of over 2000 miles, and its entire length is about 4200 miles from the mouth of the Mississippi.

Of the various other western branches of the Mississippi, the Platte, the Arkansas, and the Red rivers are the chief.

East of the Mississippi the Mobile and the Apalachicola are the chief rivers flowing into the Gulf, none of them navigable far from their mouths.

West of the Mississippi and draining the Texas slope the chief rivers are the Sabine, the Brazos, and the Rio Grande; the latter (rising in the Rocky Mountains) is 1500 miles long, and has numerous tributaries. The rivers of Texas are, on the whole, shallow and their navigation very uncertain. Several other rivers have much importance in the drainage-system, but are not suitable for navigation.

The lakes of this drainage-region also lie in the northern part. About the head-waters of the Mississippi proper and its tributaries there are many thousands of small lakes (see p. 52), none of which are very noted.

In the Rocky Mountains on the tributaries of the Missouri there are also numerous lakes, of which Yellowstone Lake in the National Park is the most famous.

33. **Rivers Flowing into the Pacific Ocean.**—Columbia River rises in the Rocky Mountains in British America, and after a circuitous course enters the State of Washington and breaks through the Cascades and Coast Ranges to the sea. The Snake River is its largest tributary; it rises in the Wind River Mountains and traverses the Columbian Plateau, uniting with the Columbia east of the Cascades. The Willamette traverses the fertile valley between the Cascades and Coast Ranges. (See p. 129.)

None of the rivers of Oregon and Northern California between the Columbia and the Golden Gate are navigable. The Sacramento and San Joaquin rivers of California drain the western slope of the Sierra Nevada, flow into the Bay of San Francisco, and find their way to the sea through the Golden Gate.

The Colorado River has its source in the Wind River Mountains, near the sources of the Yellowstone and the Snake rivers. Its upper portion is called the Green River; it takes the name Colorado only after the junction of the Green with the Grand River. For 300 miles the Colorado flows through the Grand Cañon, which in places is more than a mile deep (see p. 47), and finally reaches the Gulf of California; only the lower portion is navigable. Its chief branches are the Little Colorado and the Gila.

Most of the lakes of this region are of small size; some of the larger are Cœur d'Alene and Pend Oreille in Idaho, the Klamath lakes, which are partly in Oregon and partly in California, and Tulare and Clear lakes in California.

In the Sierra Nevada and Cascade ranges are numerous small lakes without name or fame, except, perhaps, Crater Lake (see p. 53), in the Cascades of Oregon, which is noted for its great depth and its high walls, and Lake Tenaya, near Yosemite in California, which, lying at an elevation of 8000 feet, is noted for its picturesque surroundings.

34. The **Rivers of the Great Basin** are mostly small; they are uncertain in volume and are not navigable. The river Jordan and Bear River rise in the Wasatch Range and flow into Salt Lake. Sevier River also rises in the Wasatch Mountains, and empties its waters into Sevier Lake. Humboldt River, which drains the Humboldt Mountains, flows westerly into a sink. Truckee River, the outlet of Lake Tahoe, flows northward into Pyramid Lake; Walker's River flows eastward from the Sierra Nevada into Walker's Lake.

Owen's River rises in the Sierra Nevada and runs southward into Owen's Lake. There are various other streams dignified by the names of rivers, some of which are mere brooks, and all of them very variable in volume.

The lakes of this region are partly fresh and partly salt. Bear Lake on the Bear River, Utah Lake on the river Jordan, and Lake Tahoe at the eastern base of the Sierra Nevada, are the more noted of the fresh-water lakes.

Great Salt Lake, which receives the waters of the Jordan and Bear rivers, is the largest of the salt lakes, although much smaller now than in an earlier period of the earth's history. There are numerous other lakes, such as Pyramid Lake, Owen's Lake, Walker's Lake, and Mono Lake, which vary greatly, not only in saltness, but in the chemical constitution of the materials dissolved. Soda Lake contains carbonate of soda; Mono Lake, salts of soda and borax; and others are variable in the chemical composition of their waters.

Questions.—Into what divisions are the rivers of the United States classified? What is the important feature of the St. Lawrence System? Name some of the rivers flowing into the Atlantic. Which one is of the greatest commercial importance? Describe the principal river flowing into the Gulf of Mexico. Name some of its important tributaries. What is the character of the other rivers flowing into the Gulf of Mexico? What are the important rivers of the Pacific System? Are they as well suited for navigation as the rivers of the Atlantic Slope? Describe the rivers of the Great Basin.

V. Climate.

35. The United States lies entirely in the North Temperate Zone, and embraces every variety of climate that characterizes that zone.

The climate of the portion of the country east of the Rocky Mountains differs from that of the western portion to a greater extent than is indicated by the isothermal lines.

The average temperature of the United States, as a whole, is a little more than 50°, but it is next to impossible to describe the climate of the entire region, for, on account of its great extent and the disposition of its mountain-systems, it has a variety of climates. Neither the temperature, the rainfall, nor the character of the winds is the same in different sections.

The temperature of the coast regions is modified by the influence of the sea, as has already been described. (See p. 92.) The winters are warmer and the summers cooler than those which prevail in the interior, and the range of temperature is less. A greater uniformity is noticeable on the Pacific coast than on the eastern sea-board, along which flow the waters of the cold polar current.

36. A **Tropical Climate** reaches the United States only at the extreme southern portion of Florida and in a narrow strip in the southern part of New Mexico and Arizona.

37. A **Sub-Tropical Climate** may be said to prevail between the annual isothermals of 76° and 68°. (See map of annual isothermals, pp. 70–71, also maps of summer and winter isothermals, pp. 72 and 73.)

In the region east of the 98th meridian the air contains more moisture and the heat of summer rarely rises to 100°, while in the western part it sometimes rises to above 110°. In the western part of the country the productions of a sub-tropical climate are found even beyond the isothermal line of 68°, where the Pacific Ocean tempers the extremes of heat and cold.

38. A **Warm Temperate Climate** lies between the isotherms of 68° and 53°. That portion of this belt which lies between the lines of 60° and 68° and east of the Mississippi River includes the most noted cotton region of the globe. Between the isotherms of 60° and 53° are the noted tobacco regions of the country; the northern portion of this belt is also celebrated for its corn. The western portion, lying in California, produces many sub-tropical plants, such as the orange, fig, olive, almond, etc., which do not flourish in the eastern sections because of the colder winters.

39. A **Temperate Climate** may be said to lie chiefly between the isotherms of 53° and 39°.

The great corn region of the Mississippi Valley lies chiefly between the annual lines of 53° and 46° and east of the 100th meridian; most of the wheat and oats of the country is also grown in this belt, but the region in which these cereals are cultivated extends to the east and to the west on either side of the 100th meridian.

The range of temperature in the United States east of the Rocky Mountains is exceedingly great. Some of the weather-maps of the Signal Service show that in winter the thermometer sometimes indicates a temperature more than 40° below zero, near the borders of North Dakota and Montana, while the column of mercury stands more than 80° above zero at the same instant in Southern Florida. This range of more than 120° at the same moment shows more impressively than any other fact the great diversity of climate found within the limits of this country.

It will be seen from the map that the mean isothermal lines run southward near the Pacific. The vegetation, however, is not correspondingly limited by these lines, as the climate of the western coast is very much more uniform than that of the eastern.

The United States has an extensive weather signal service to give notice of the approach of storms, changes of weather, etc., which has already been described on pp. 81–83.

40. **Rainfall.**—The rainfall of the United States varies greatly in its different sections, both as to the quantity and as to the season during which the rains are prevalent.

East of the Great Plains rain falls in every month of the year, and in most of the States east of the Mississippi River the difference between the average rainfall of any one month when compared with that for another month is not very great.

The annual rainfall for most of the region east of the Mississippi is from 35 to 50 inches. (See map of rainfall, pp. 84–85.) Westward, the rainfall varies greatly as to quantity and as to the time of falling. The Pacific States have a wet and a dry season, and the rainfall of different years is more variable than that of the Eastern States. (See p. 86.)

Rain falls quite equally on both slopes of the Appalachians, but in the Cordilleran System the relative proportions of the precipitation on the two slopes are very unlike. The difference is most marked on the Sierra Nevada and on the Cascade Range, where the western slopes sometimes receive tenfold more rain than the eastern slopes; in this region two localities, but a few miles apart, frequently receive very unlike quantities of rain. The local differences of rainfall are too great to be satisfactorily shown on a map, unless it be drawn on a very large scale.

Along the Pacific coast the winds from the ocean are laden with moisture, and where the conditions are such as to lower the dew-point and to cause condensation there is a precipitation of rain. In Washington, where the Kuro Siwo warms the adjacent waters, there is generally a marked difference between the temperature of the sea and that of the land. The moist winds are thus chilled and rains are frequent at all seasons of the year. Farther south the land is warmer than the sea in summer and colder in winter, consequently these regions have a wet and a dry season. In portions of Southern California, where the temperature of the land is in general higher than that of the sea, little or no rain falls.

The rainfall of the Great Basin, and, in fact, of the whole western plateau region, is very light. The atmosphere is also extremely dry and evaporation is rapid. The moisture is intercepted by the mountains between these regions and the ocean. The Indians and pioneer hunters were accustomed to cure the flesh of the bison by simply drying it in the open air.

41. The distribution of the animal and the plant life in the United States has already been discussed, and as this country occupies the central part of the continent, its flora and fauna are intimately related to those of the regions on either side; the distribution of life is also related to the climate and to the geological history of the country. Special enumeration of the species belongs to Zoology and to Botany, rather than to Geography, and would include all the species of British America and many of those of Mexico.

The names of the different indigenous and cultivated plants, and the section of the country in which each grows, as well as the distribution of the native and the domestic animals, are much more fully and conveniently indicated on a map than by descriptive text. In studying the physical features of the United States a careful examination of the map (pp. 130–131) will be of great service in acquiring an idea of the diversity and abundance of plant and animal life.

Questions.—Can the United States be said to have a homogeneous climate? Where is the climate most uniform? Where is a tropical climate found? Where does a subtropical climate prevail? In which part of the country is the air relatively more moist? Between what isotherms is a warm temperate climate found? A temperate climate? What isotherms enclose the cotton region? The tobacco regions? The corn region? What is the range of climate in the United States? In what part of the country is the rainfall most regular? How does the rainfall of the western differ from that of the eastern section *of the country*?

VI. Geology of the United States.

42. The dry land of the globe, although it appears so fixed and unchangeable, and though within a lifetime, or even within the history of man, it has scarcely varied in form, has, nevertheless, not endured for a long period in any one shape.

When the earth first cooled from its molten condition (see p. 11), its original surface was composed of crystalline rocks, which were in all probability submerged beneath the surface of an endlesss ocean. As the cooling process continued, the shrinking and wrinkling of the crust thrust certain portions of the solid surface above the level of the waters, to be subjected to the ceaseless erosive action of the sea and of the rain.

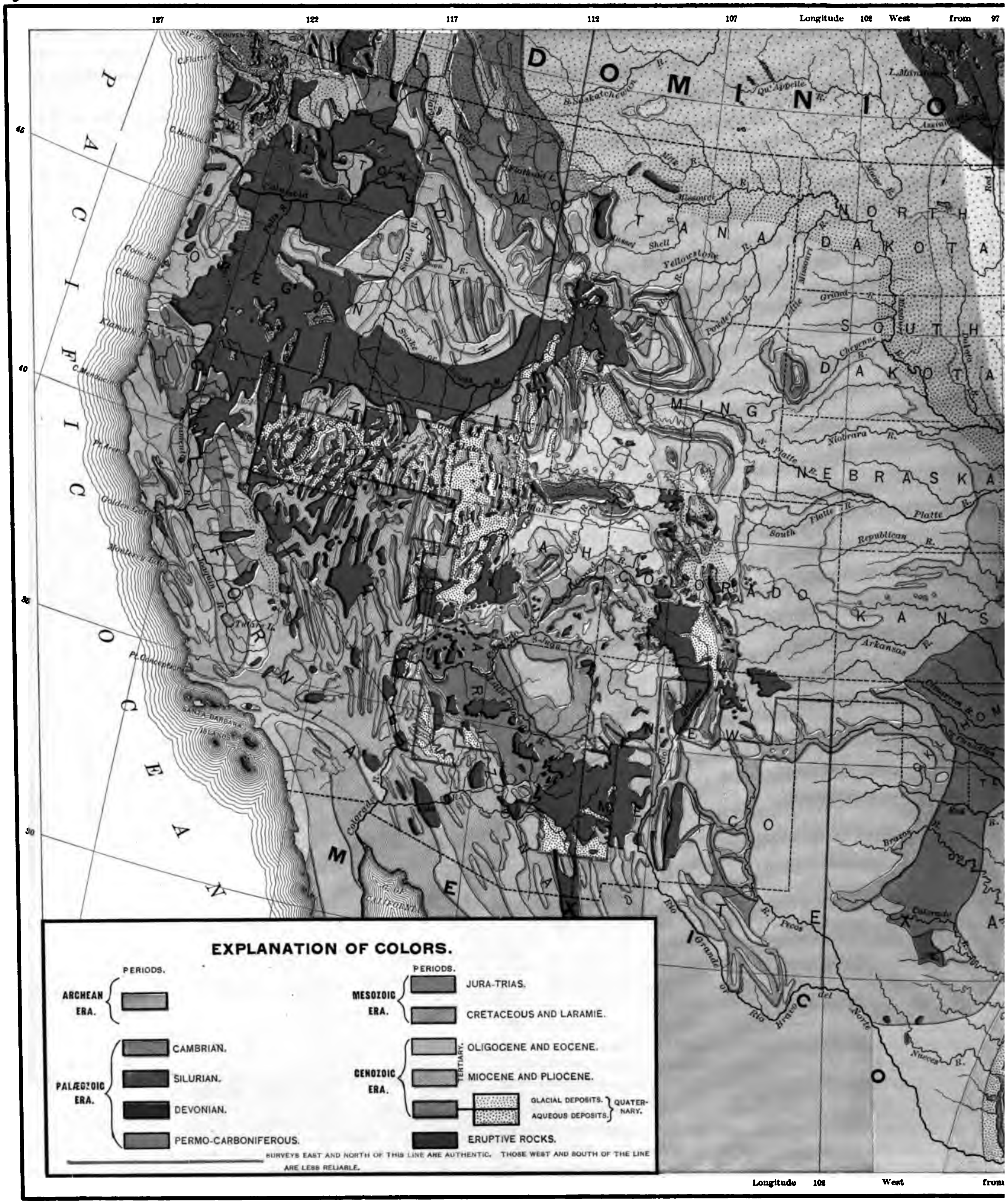
As these primitive rocks were slowly disintegrated and washed back into the ocean, strata were formed on its bed, which, in turn, were uplifted in places, so that the greater part of the land-surface now visible was formed on the floor of the sea, and subsequently raised to its present position. The rocks near the very summit of some of the highest mountains contain marine fossils, and the limestones are but the legacy of sea-animals which lived and perished in former ages. (See pp. 11–16.)

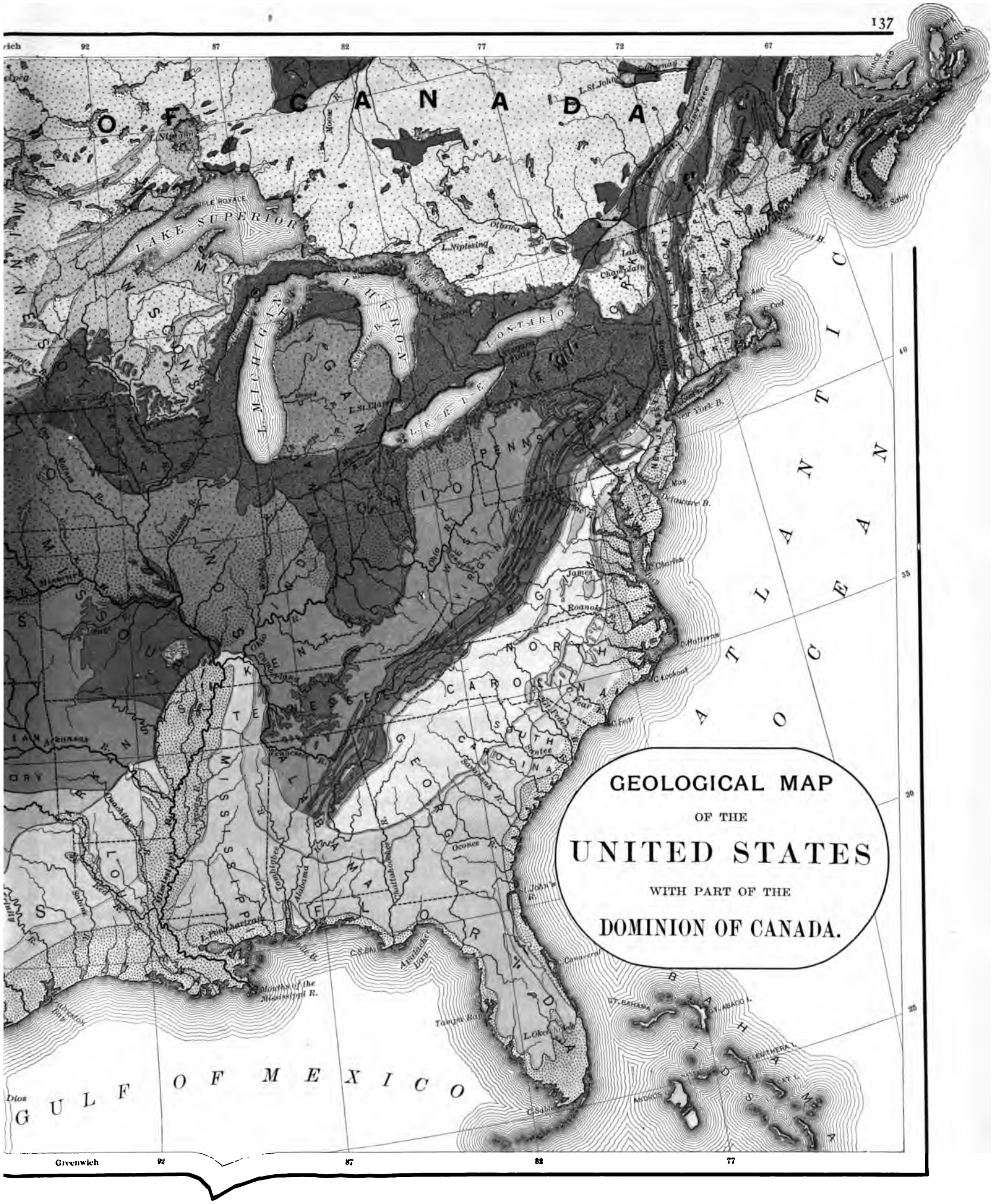
Though the areas thus exposed have been always yielding to the destructive forces of the rain-storm, of the glacier, or of the atmosphere, and while many of them have again been buried beneath the sea by new crumplings and shrinkings of the crust, yet from the time the land first made its appearance above the level of the waters it has gradually increased in area. In the successive periods of the geological ages new lands have appeared and the mountain-chains have assumed their present form. (See pp. 11 and 12.)

43. During the **Archæan Era** (see p. 15) a considerable mass of land appeared in the northern portion of the continent of North America. The greater part of this land-area was about Hudson Bay, extending northward to Greenland. In the United States there was comparatively little land. Near the present site of Lake Superior there were large islands, but most of them were in the Dominion of Canada. In New England were other and mountainous islands, from which a group extended southward for a distance, somewhat indefinitely determined, along the line of what afterward became the Appalachian Mountains. There were also a few islands where the great Cordilleran System now exists. (See Archæan rocks on the geological map, pp. 136–137.)

44. During the **Palæozoic Era** (see p. 15) there were enormous additions to the land of this continent. This increase occurred in each of the three ages, the last of which was the Carboniferous Age, or the age of coal. At its close the land existed as two great groups of islands, one extending along the trend of the Appalachian System, and the other in the west following the direction of the Cordilleras. Between these great archipelagoes the waters of the sea flowed from the Gulf of Mexico to the Arctic Ocean. The Atlantic and Pacific oceans were also united where the Isthmus of Panama and Central America are now found.

45. During the **Mesozoic Era** (see p. 16) the land between these two mountain-systems became joined. Great bays which extended into the Cordilleran System were cut off from the sea, and became, at first, brackish, and, finally, fresh-water lakes. Around these inland bodies of water there were extensive swamps and magnificent forests. Many reptiles and other animals inhabited these regions; all of them were of strange forms and some of them were of monstrous size.


127
122
117
112
107
Longitude 102 West from 97
PACIFIC OCEAN
DOMINION
MONTANA
NORTH DAKOTA
SOUTH DAKOTA
OREGON
IDAHO
WYOMING
NEBRASKA
NEVADA
UTAH
COLORADO
KANSAS
CALIFORNIA
ARIZONA
NEW MEXICO
MEXICO
EXPLANATION OF COLORS.
PERIODS.
ARCHEAN ERA.
CAMBRIAN.
SILURIAN.
DEVONIAN.
PERMO-CARBONIFEROUS.
PALÆOZOIC ERA.
PERIODS.
MESOZOIC ERA.
JURA-TRIAS.
CRETACEOUS AND LARAMIE.
CENOZOIC ERA.
TERTIARY.
OLIGOCENE AND EOCENE.
MIOCENE AND PLIOCENE.
GLACIAL DEPOSITS.
AQUEOUS DEPOSITS.
QUATERNARY.
ERUPTIVE ROCKS.
SURVEYS EAST AND NORTH OF THIS LINE ARE AUTHENTIC. THOSE WEST AND SOUTH OF THE LINE ARE LESS RELIABLE.
Longitude 102 West from


GEOLOGICAL MAP
OF THE
UNITED STATES
WITH PART OF THE
DOMINION OF CANADA.
C A N A D A
O F
LAKE SUPERIOR
L. MICHIGAN
HURON
ONTARIO
ERIE
PENNSYLVANIA
NEW YORK
VIRGINIA
NORTH CAROLINA
SOUTH CAROLINA
GEORGIA
FLORIDA
ALABAMA
MISSISSIPPI
LOUISIANA
TEXAS
GULF OF MEXICO
ATLANTIC OCEAN
BAHAMA ISLANDS
Greenwich
92
87
82
77
72
67
40
35
30
25

51. **Lake Lahontan,** at the eastern base of the Sierra Nevada, covered more than 8000 square miles. (See p. 89.) It was very irregular in shape, had numerous islands and promontories, and must have been one of the most picturesque lakes on the globe. Volcanoes within it or on its shores poured out great volumes of ashes, which spread over its bottom, forming strata. The waters of this lake have almost entirely disappeared: salt lakes, saline swamps, or alkaline plains occupy the lower depressions, but most of its bed is now dry and desert. (See p. 93.)

52. **Lake Bonneville,** at the eastern base of the Wasatch Mountains, was even more interesting. It was more than twice as large as Lake Erie, but like Lake Lahontan it has dwindled to a mere fraction of its original size: Salt Lake is about all that is left of it. It, too, was very irregular in outline; several mountain-chains then ran into it, forming both peninsulas and promontories, and some peaks stood as islands in the water. This lake had an outlet which flowed northward through Red Rock Pass to the Snake and Columbia rivers.

The broad desert west of the Great Salt Lake occupies a part of its bed. (See map of Lake Bonneville.) Its old shores are marked by wonderfully distinct terraces, which extend along the sides of the mountains for more than 100 miles southward from the present Salt Lake. In places a series of these terraces lie one above the other. These old shore-line terraces constitute one of the most conspicuous features of the scenery of Utah.

53. **Lake Agassiz** occupied a region mostly in North Dakota, but extending into Minnesota and Canada. Much of its ancient bed is nearly as level as the sea, and on it are found the most famous wheat-fields of North Dakota and Minnesota. It is now drained by the Red River of the North into Lake Winnipeg, and thence by the Nelson River to Hudson Bay.

54. After the great glaciers began to melt, there was a period of immense floods along the valleys. Many of the lakes were thus formed, and the rivers of that time were much larger than the present streams. The material which had been worn off and pulverized by the moving ice was now transported by the rivers and deposited along their banks or on the beds of the lakes.

55. **Terraces.**—In the north-eastern part of the country, and more especially in New England, some of these ancient lakes have been drained by erosion or by other geological changes. Their old shore-lines exist as terraces in many valleys and are conspicuous features in the landscape. Several towns and cities in the Connecticut Valley occupy these terraces.

The clay and mud which settled in some of these extinct lakes constitute now some of the most fertile land of the north.

Some of these lakes have disappeared in modern times. A lake a mile and a half long and 150 feet deep, in Northern Vermont, was suddenly destroyed by the breaking of its barriers in 1810; the place is now known as Runaway Pond; forests clothe the sloping sides and meadows stretch across what was once the bottom of the lake.

Questions.—How were the first land-areas formed? Has the land-surface been fixed and unchangeable? How does its area at the present time compare with that of the earlier ages? What appearance was presented by the continent of North America during the Archæan Era? What was the condition at the end of the Palæozoic Era? When did the eastern and the western portion of the continent become united? What interior bodies of water were formed? What were some of the peculiarities of the animal life at this time? What changes occurred in the Cænozoic Era? Describe the extent of the glaciers during the Ice age. What were the character and effect of the rainfall? How were lakes formed? What three great lakes of ancient times have disappeared? Describe Lake Lahontan. *Lake Bonneville.* *Lake* Agassiz. What topographical formation marks the shores of the *lakes and streams of these early periods?*

VII. Mineral Resources.

56. The United States is especially rich in mineral wealth. Its more valuable mineral productions may be considered in the following divisions: building-stone and clays; salt; coal, petroleum, and gas; the useful metals; the precious metals; and precious stones and ornamental marbles.

57. **Building-Stones** of great variety are found widely distributed. Granite and gneiss are most abundantly quarried in New England, but occur in nearly all the portions of the country where there are mountains. Sandstones of great variety as to texture, durability, and color are also abundant. Those of New England, New York, and New Jersey are, as a rule, more red than those of the Central Valley. Limestones and marbles occur of very wide variety; they are, however, more extensively used for building west of the Hudson and south of the Ohio than in the north-eastern part of the country. Slate, for roofing and for other purposes, is quarried in New England, in Pennsylvania, and in New Jersey. Flagging-stones are extensively quarried near the Hudson River at the base of the Catskill Mountains, but they are found, of one kind or another, widely distributed.

Clays fit for brick-making occur in many places in several States and Territories of the country. Clay is also found in many localities suitable for pottery and crockery.

58. **Salt** occurs in many places; the chief supply is obtained by evaporating the water of salt springs, notably in Michigan and in New York. It is also obtained by the evaporation of sea-water and from some of the salt lakes of the Great Basin.

Beds of rock-salt are mined on the island of Petit Anse, on the southern coast of Louisiana. Salt beds also occur in many valleys in the Great Basin; from some of these it is obtained in paying quantities. Extensive beds of salt have been found by boring in Central New York, but none of them are worked.

59. **Borax** is found in Borax Lake in California, and in various saline swamps in the western portion of the Great Basin, both in Nevada and in California.

60. **Coal** is a kind of fossil vegetation. At a remote period of the world's history extensive marshy areas were covered with a luxuriant vegetation; as this swampy growth fell and decayed, it was eventually covered with other material, and during succeeding ages became transformed into the coal which is so abundantly found in many parts of the country. The most extensive deposits are those of the Carboniferous Age. (See p. 16.) It is estimated that coal-fields to the amount of 192,000 square miles occur in the United States east of the Rocky Mountains, 120,000 square miles of which are estimated to contain workable beds of coal. There are also coal-mines in Colorado, in California, and in other Western States.

The coal-fields lying on either side of the Appalachians and extending westward to Missouri and Texas are of the Carboniferous Age. Those of the Cordilleran region are either Cretaceous or Tertiary, and differ in texture and quality from the Carboniferous fields.

61. **Petroleum,** which, by derivation, signifies "rock-oil," is a substance which exudes from the rocks of various geological ages. Since 1859 it has been extensively procured by boring in certain rocks which contain it. Petroleum has been most largely produced in Western Pennsylvania, West Virginia, Ohio, Michigan, Kentucky, and Tennessee, to some extent in California, and in small quantities in other places.

62. **Natural Gas** is also found in many petroleum regions, and is probably derived from the same source, the decomposition of organic matter (both animal and vegetable) enclosed in the stratified rocks. It is extensively used for fuel, especially in Western Pennsylvania.

63. **Iron,** the most useful as well as the most common of all metals, is widely and abundantly distributed in the United States.

Iron does not occur in its pure state, but is combined with other substances, forming ores. Valuable iron-ores are found in nearly all the States of the Union. It is so abundant that it has commercial value only where it is of great purity or where the advantages for working it are exceptionally good. There are extensive deposits in North-eastern New York about the Adirondacks, around Lake Superior in Michigan, in Pennsylvania, and southward in the Appalachian Chain. In Missouri they are so abundant as to form two iron mountains, one of which (Pilot Knob) is 581 feet, and the other 228 feet, in height.

64. **Copper** is found both in its metallic state and in combination with other elements, forming ores. There are many rich deposits of copper in the United States. Productive mines in the Appalachian region have been worked in Vermont, Connecticut, New Jersey, Pennsylvania, Maryland, and Eastern Tennessee.

The copper region of Lake Superior is perhaps the most remarkable in the world. The metal occurs native—that is, not combined with other elements. One mass of metal was taken from one of the mines weighing four hundred and twenty tons and containing more than 90 per cent. of pure copper. Copper-ore is found in numerous places in the Cordilleran System, and is worked in many localities. Most of the copper of the country is produced in the Lake Superior region and in Montana and Arizona.

65. **Lead** is next in importance among the useful metals. It, too, has been mined in numerous localities. The greatest quantities, however, occur in the valley of the Mississippi. A very large part of the lead supply of the country comes from Missouri and Kansas, and from the limestones of Wisconsin, Iowa, and Illinois; large deposits are found in Colorado and in Utah. In many mines in the Cordilleran System lead is associated with silver.

66. **Zinc-Ores** are found in various places in the Appalachian region from Maine to Virginia and Tennessee, and in the Mississippi Valley. Zinc-ores are worked in New Jersey, Pennsylvania, and in numerous places in the Central Valley. Zinc is extensively used in making brass.

67. **Tin-Ore** has been found in various parts of the Western United States, and mines have been worked in several places, chiefly in California and in the Black Hills of South Dakota, but the production is small.

68. **Chromium** exists widely distributed, and has been worked in several States; the largest deposits are in New Jersey, Pennsylvania, and California. Its chief uses are in manufacturing paints and dyes.

69. **Nickel** occurs in several places, particularly in Pennsylvania and Nevada. Alloyed with copper and zinc, it forms the well-known German silver, and is extensively used for plating iron-ware and for hardening silver and copper coins.

70. **Antimony, Manganese,** and **Cobalt,** all of them materials for use in the arts, are found in various places and are more or less worked. Types used for printing are made from an alloy of antimony and lead.

71. **Quicksilver,** or **Mercury,** occurs both native and in combination with sulphur, forming the red ore called cinnabar. Nearly all produced in this country comes from California. The mines of New Almaden and of New Idria have furnished the most to commerce, but there are numerous other mines in that State; all are in the Coast Ranges, and they extend from the San Joaquin Valley to Clear Lake. Quicksilver is most extensively used in extracting gold from rocks and sand.

72. **The Precious Metals.**—The precious metals comprise gold, silver, and platinum. Both platinum and silver are found in the Appalachian region, and gold occurs in considerable quantities from Virginia and Maryland to South Carolina.

73. **Gold** is found, in its metallic state or native, diffused through the rocks or mixed with sand which has been derived from their decomposition or erosion. In the Appalachians it is widely distributed in small quantities, but it occurs in far greater abundance in the Cordilleran System, which produces nearly all the gold and silver of the country. The metal is extracted from the pulverized rock or the gold-bearing sand by the use of quicksilver.

Each of the States and Territories in the Cordilleran region has produced both gold and silver, but the quantities obtained have varied with the locality. In California it is mostly obtained on the western slope of the Sierra Nevada; in Nevada it occurs mostly in combination with silver in certain ores; in the other States it is sometimes washed from the sands, sometimes obtained by pulverizing quartz, and sometimes found mixed with silver-ores. It is also found in the Black Hills of South Dakota and in Alaska.

74. **Silver** is found as a native metal in the copper region of Lake Michigan and on an island within the lake, but much more extensively in the Cordilleran region, every State and Territory of which has numerous mines.

The most extensive silver-mines of the world, and those which have produced the most silver during the last thirty years, are in the Washoe district of Western Nevada, on what is known as the Comstock Lode. There are more than 200 miles of underground workings in these mines, and they extend to a depth of over 3000 feet. These, although they are called silver-mines, yield much gold also, and have produced bullion worth more than $320,000,000. The production of gold and silver from the Western United States has been so great during the last forty years that values have changed all over the world. The quantity of silver has been so great during the last thirty years that that metal has universally declined in value, and in most European countries has ceased to be the standard of valuation for coins.

75. **Platinum** is found with gold in a few places, but the amount obtained is comparatively insignificant.

76. **Precious Stones** and **Ornamental Marbles** of considerable variety and beauty have been found in many places, but the actual production is small.

Questions.—What is the character of the mineral resources of the United States? Name some of the abundant varieties of building-stones. How is salt obtained? Where are the chief sources of supply? Where does rock-salt occur? What is the extent of the coal-fields? Where are they situated? Where is petroleum mainly produced? For what is natural gas used? Where are some of the extensive deposits of iron-ore? Where are some of the copper regions situated? In what sections are the important lead-mines? Where is zinc found? Tin? Chromium? What are some of the uses of nickel? Where is quicksilver most abundant? Name some of the other useful metals. Where are the most noted gold regions? Where are the silver-mines? What other valuable metal and minerals are found in limited quantities?

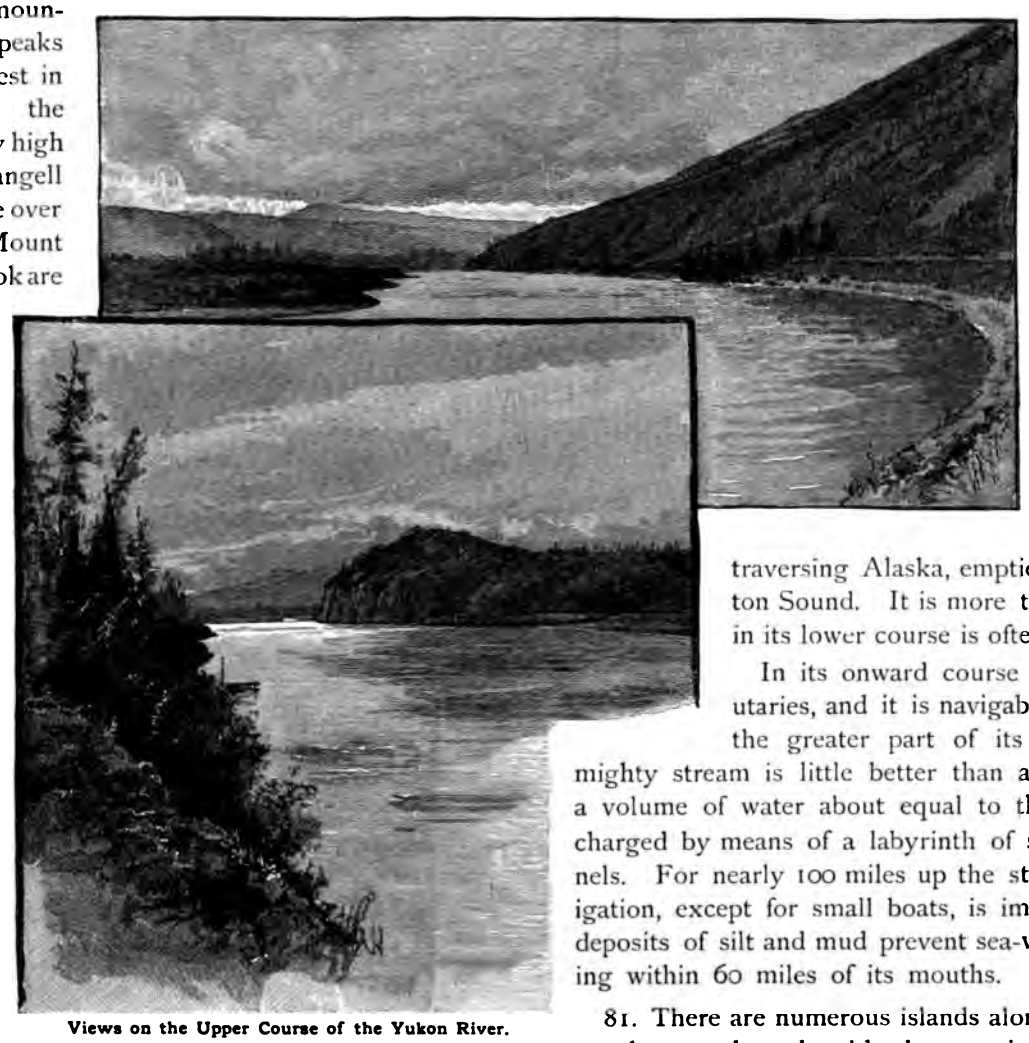
VII. Alaska.

77. The great extent of Alaska is seldom appreciated on account of the reduced scale employed in representing it on the maps; but a careful observation shows that from its eastern boundary to the western extremity of the Aleutian Islands this great territory extends through nearly the same number of degrees of longitude as the main body of the United States.

The distance between its eastern and its western limits is about 2000 miles, and a line drawn from its southern boundary to Point Barrow is over 1100 miles in length. The superficial area of Alaska is considerably more than 500,000 square miles, or about one-sixth of the entire area of the United States and Territories.

78. Its surface is mountainous; some of its peaks are not only the highest in North America, but the most lofty found in any high latitude. Mount Wrangell and Mount St. Elias are over 18,000 feet high; Mount Crillon and Mount Cook are about 16,000 feet, and numerous other peaks, above 14,000 feet in height.

On the slopes of these mountains are the grandest glaciers found outside of Greenland and the Antarctic Continent; many of them come down to the sea-level. The islands and the beaches, which are strewn with boulders, furnish many indications of ancient glacial action, and the number of glaciers existing in this region to-day is estimated at more than five thousand.



Views on the Upper Course of the Yukon River.

Several efforts have been made to ascend Mount St. Elias for the purpose of ascertaining its exact height, but as all approaches to it are peculiarly difficult of access, and as its sides are remarkably steep and covered with perpetual glaciers, all attempts to gain the summit have been unsuccessful. In 1892, however, a series of measurements made by direction of the United States Coast Survey Department determined the height of the mountain to be 18,010 feet.

Mount Wrangell, situated at the junction of Copper River and one of its tributaries, is, according to the triangulations of Lieutenant Allen, 18,640 feet above the plateau at its base, and, as that is more than 2000 feet above the sea-level, a height of 20,000 feet is claimed for this volcanic peak.

The higher mountains are of volcanic origin, and the Aleutian Islands are the extension of a volcanic chain partially submerged in the sea. Most of these volcanoes are extinct, but a few are active. There have been grand eruptions on the Aleutian Islands *within very* recent years.

Much of the lowland expanse of Alaska consists of vast reaches of "Tundra" or swamps, which are frozen in winter, and which, thawing to a slight depth in summer, constitute saturated spongy wastes covered with moss and tufted grass.

79. The climate of Alaska is cold and wet, but more uniform and much milder than that prevailing in the corresponding latitudes of the eastern coasts of North America.

Along the coast, south of latitude 60°, the summers are moderately cool and wet, and the winters are not very cold. The northern portion is much colder, and at Point Barrow, within the Arctic Circle, the ground is permanently frozen to a great depth.

Along some portions of the Arctic coast there are strata of permanent ice covered with soil supporting a summer vegetation. These ice-cliffs are but slowly undermined by the waters of the ocean.

Fogs and rain are of frequent occurrence. Along the coast region in the vicinity of Sitka the annual rainfall amounts to about 85 inches. From November until April or May, snow and sleet prevail with almost unceasing monotony; thunder and lightning often accompany the severe snow-storms, but during the summer thunder-storms are unknown.

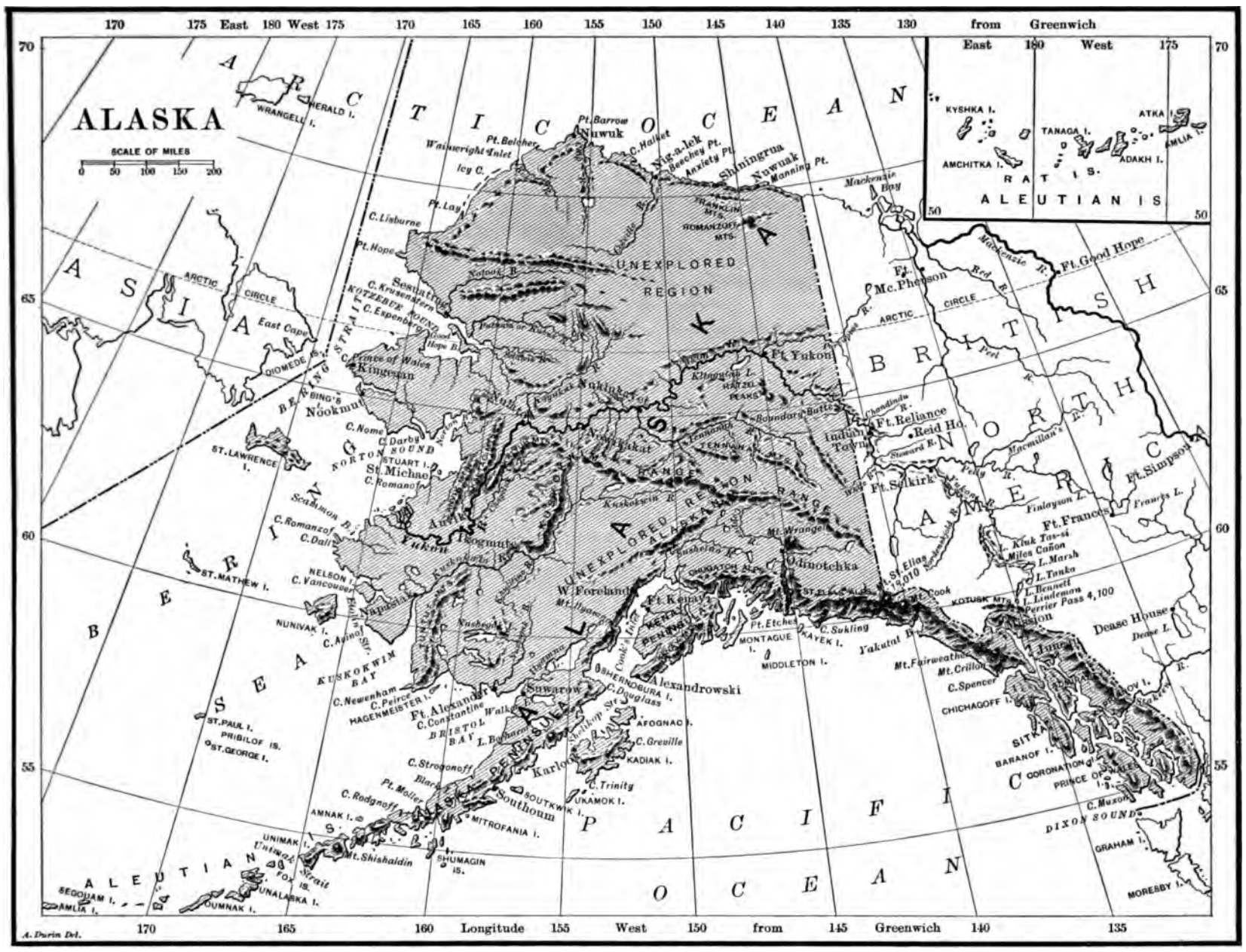
80. There are numerous rivers, but the Yukon is much the largest; it rises in British America, and, after traversing Alaska, empties by many mouths into Norton Sound. It is more than 2000 miles in length, and in its lower course is often more than 20 miles wide.

In its onward course it receives several large tributaries, and it is navigable for small craft throughout the greater part of its length. The delta of this mighty stream is little better than a vast swamp, through which a volume of water about equal to that of the Mississippi is discharged by means of a labyrinth of shallow and misleading channels. For nearly 100 miles up the stream from the coast-line, navigation, except for small boats, is impracticable, and the immense deposits of silt and mud prevent sea-worthy vessels from approaching within 60 miles of its mouths.

81. There are numerous islands along the coast from Mount Fairweather southward, with deep navigable channels between them. Vessels pass all the way from Puget Sound to Sitka through the various passages between the islands and the mainland, and are obliged to encounter but a few miles of open sea. This course has become a popular summer trip because of the sublime scenery along the route.

82. Gold is found in numerous localities. Placer-mines have been worked on some of the various streams, and quartz-mines have been developed in a few places. Coal is found at a number of different points, but is not of good quality. Copper-ore is abundant, but is not worked in competition with the Lake Superior and Montana mines.

The placer-diggings at Juneau City, a little village situated near the upper end of Gastineaux Channel, and the large gold-quartz stamp-mill operated by the owners of the Treadwell Mine, on Douglas Island near by, represent the principal active mining industries.



Map of Alaska.

There are many places in which gold can be obtained in paying quantities, but on account of their unfavorable location most of them have been abandoned by the miners.

83. Extensive forests of pine, fir, spruce, and cedar exist, but the land has only limited agricultural possibilities.

Fur-bearing animals abound, and of these fur-seals are the most important. These animals are now very scarce in all the other regions of the world where they were once abundant, except on the small Pribilof Islands in Bering Sea; here they have been protected by the government, and only a limited number is allowed to be slain each year. They constitute an important source of revenue to the government, and it is hoped that these interesting animals may be thus saved from extermination.

The fisheries of Alaska are important. There are many species of fish, but those which are of the chief commercial value are the cod in the open sea and the salmon in the rivers. Enormous quantities of salmon are canned annually.

The seal islands are also frequented by sea-lions, which are much larger than the fur-seals and are killed by the natives for food, but their hides are not covered with fur and their only use is in constructing canoes. The Eskimos, especially those who inhabit the northern islands, depend largely for their food-supply upon the flesh of the walrus, an animal which has a tough skin devoid of hair or fur. The sea-cow, the largest of the amphibians except the whale, is now extinct, and the sea-otter, whose fur is prized above that of all other Arctic animals, is rapidly disappearing.

Some parts of Alaska are so infested with mosquitoes as to be uninhabitable, not only by the native Indians, but also by the large land animals.

84. At a not remote period the climate of Alaska must have been very much more mild and its organic life much more abundant. A species of elephant now extinct was once so abundant that fossil ivory is found in large quantities. Enormous tusks are found in great numbers over a large region, and in such good preservation that they form an important article of commerce, constituting the "yellow ivory" of the arts.

Questions.—How do the easterly and westerly dimensions of Alaska compare with those of the main body of the United States? What is its surface-area? What is the character of the surface? Describe the glaciers. What is the nature of the higher peaks? The character of the lowland sections? How does the climate compare with that of corresponding latitudes on the eastern coast? Describe the rainfall. Which is the most important river? What is the character of the coast? What are the mineral resources of Alaska? Are any portions of the country forest-clad? What are the possibilities of agriculture? What important animals are found in Behring Sea? What is the value of the fisheries? What changes of climate have occurred? What fossil product has a commercial value?

REVIEW AND MAP QUESTIONS.

What constitutes the entire domain of the United States? What are the boundaries of the main portion? What is its length in an easterly and westerly direction along the 40th parallel? Its length along the 98th meridian from the Rio Grande to the northern border?

Are there many projecting peninsulas on the coast? What dangerous cape is situated on the Atlantic coast? Name the most western cape. What series of islands lie south of New England? What are the most important islands on the Pacific coast?

In what part of North America do the two dominant mountain-systems attain their greatest development? Which is the primary axis? Which is of the greater political and historical interest? What is the extent of the secondary system? How does the northern differ from the southern part? What two passes have played an important part in the history of the country? Which is the most extensive of the three sections of the Appalachian System? Name some of the mountain-groups and ridges belonging to this section. Which is the highest peak? What is the character of the valleys between the ridges?

How does the width of the Atlantic coast-plain vary? What is the character of the country between the coast region and the mountains? Describe the Piedmont Plateau. In what region do swamps occur? Of what great line of elevation is the Cordilleran System a part? Where does it attain its greatest width? Where are the Rocky Mountains? How are they disposed? Describe the northern group. The southern group. What railroad passes between the two groups? What parks are found in the southern group? Where is Yellowstone Park? What group of mountains is detached from the main system? What area of interior drainage is included between the ranges of the Cordilleras? Describe its extent and area. The character of its valleys. For what are the Washoe Mountains noted? Which portion of the Great Basin is the highest? What portions are below the sea-level?

What plateau lies north of the Great Basin? By what river is it drained? What is the character of the river-beds? Of the soil? What plateau is south of the Great Basin? For what is it remarkable? What great chain forms the western boundary of the Cordilleras?

Describe the surface of the Great Plains. The rivers of this region. The dunes. What is the character of the country between the two mountain-systems? What elevations are found in this region? What is the nature of the soil?

What is the general character of the rivers of the United States? Where do most of the large streams rise? What lakes are connected with the St. Lawrence System? In what portion of the Atlantic slope are there but few lakes? What is the greatest length of uninterrupted navigation on the Mississippi? Where are the lakes of the central region? Name some of the characteristics of the rivers flowing into the Pacific. Describe the lakes of the Great Basin.

What is the average temperature of the United States? What varieties of climate are observed? Is the rainfall uniform? What region has a wet and a dry season? What are some of the peculiarities of the rainfall in the western part of the country?

What portion of North America first appeared in the early geological ages? Along what lines of elevation did the land continue to rise? What were some of the features of the country during the Mesozoic Era? In what era did the land assume a shape much like the present? In what period was the surface greatly modified? What glacial lakes have been specially studied?

Where is granite mainly quarried? In what ages were the coal deposits formed? What is the probable origin of petroleum? How is gold obtained?

How does the surface-area of Alaska compare with that of the United States and Territories? Where are the active volcanoes found? What is the volume *of water* discharged by the Yukon River? What are the main sources of *wealth?*

Locate the three sections of the Appalachian System. Which section has the greatest breadth? Trace approximately the eastern border of the Central Plain. Of the Great Plains. What is about the altitude of the region around the Great Lakes? Where are the greatest extents of lowland on the Pacific coast? Name some of the highest portions of the Cordilleran region. In what direction do most of the Cordilleran ranges trend? How are the rivers north of the Great Lakes separated from the St. Lawrence System?

Where is the most fertile region of the country? Locate the Great American Desert. The Everglades. The Mohave Desert. Death Valley. The Colorado Desert. What elevation lies between the Missouri River and the Red River of the North?

What is the average annual temperature of Virginia? Of South Carolina? Of the peninsula of Florida? Of the State of New York? Of the State of Washington? What cereal is raised along the southern coast region? Where is sugar-cane grown? In what sections are oranges, lemons, and figs cultivated? Where is sea-island cotton found?

What portion of the United States has the most complicated geological structure? Do the rocks of New England belong to ancient or to more recent ages? By what formation is Lake Ontario surrounded? Along what line of elevation do rocks of the same age extend?

To what age do the rocks of Southern New York belong? What lake is surrounded by this formation? Trace its extent toward the south. What formation does it surround in Ohio, Indiana, and Kentucky? Name the regions in which Silurian rocks are found.

In what part of New England is Carboniferous formation found? Trace the extent of the Permo-Carboniferous fields in the eastern part of the country. In what parts of the Cordilleran region is coal found? To what era do the rocks on the eastern slope of the Appalachian Mountains mainly belong?

Point out some of the localities in which Jura-Trias formation occurs. In which Cretaceous rocks are found. Where are the greatest extents of Eocene rocks? By what formation is Nebraska largely covered? Where are the largest Miocene deposits observed?

What formation lies immediately west of the Permo-Carboniferous in Indian Territory and Texas? What part of the country is covered by glacial deposits? Trace the terminal moraine. What deposits cover the land along the coast of the Atlantic Ocean and the Gulf of Mexico? Along what river are there extensive areas of aqueous deposits?

In what part of the country are the eruptive rocks most abundant? Where is the largest area of volcanic formation? What formations are found in New York? In Georgia? In Tennessee? In Michigan?

What are the important minerals of the Appalachian region? Which is the most noted mineral region of the country? Name some of its resources. What metals are found in the vicinity of the Great Lakes? Where is the greater part of the supply of lead obtained?

By what body of water is Alaska separated from Asia? Through what sound does part of its southern boundary extend? Where is Cook's Inlet? Bristol Bay? Norton Sound? Kotzebue Sound?

Where is Kenay Peninsula? What peninsula southwest of this? Where is Point Barrow? Cape Dall? Cape Prince of Wales? Cape Romanzof? Cape Trinity? Where is Kadiak Island? Where are the Pribilof Islands? For what are these islands noted? Where is St. Lawrence Island? Nunivak Island? Chichagoff Island? Locate Mount St. Elias. Mount Cook. Mount Wrangell. Mount Crillon.

Trace the course of the Yukon River from its source to its mouth. Where is Sitka? Juneau?

INDEX.